METROPOLITAN DISTRICT COMMISSION
DIVISION OF WATERSHED MANAGEMENT
QUABBIN SECTION

2000 WATER QUALITY REPORT

Quabbin Reservoir Watershed
Ware River Watershed

Executive Office of Environmental Affairs
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ADDITIONAL INFORMATION -

EPA Safe Drinking Water Hotline (800) 426-4791

MDC Home Page: http//www.magnet.state.ma.us/mdc

LIST OF ILLUSTRATIONS

ACKNOWLEDGMENTS

This report was prepared by the Quabbin Environmental Quality Section of the Metropolitan District Commission's, Division of Watershed Management. Scott A. Campbell, Environmental Engineer II was the principal author. David Chandler, Environmental Analyst I managed data table manipulation and maintenance. The following MDC staff provided comment on this report:

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Philip Lamothe, GIS Specialist provided Geographical Information System data and support. David Supczak, Joseph P. Burek, Peter Izyk and Doug Williams of the Quabbin Civil Engineering Section provided meteorological data reproduced in this report.

EXECUTIVE SUMMARY

The Surface Water Treatment Rule (SWTR) promulgated on June 29, 1989 established treatment technique requirements for filtered and unfiltered surface water supplies that are intended to protect against the adverse health effects of exposure to Giardia lamblia and other pathogenic organisms. Avoidance of filtration may be granted if the water purveyor demonstrates compliance with mandated source water quality criteria for coliform bacteria and turbidity, disinfection sufficient to inactivate Giardia lamblia and other viruses, and the system must not have been identified as a source of a waterborne disease outbreak. Moreover, unfiltered public water supply systems must address site-specific criteria through the maintenance of an effective watershed control program that:

- characterizes watershed hydrology and land ownership;
- identifies watershed characteristics and activities that could harm source water quality; and,
- monitors the occurrence of these activities.

The backbone of the current watershed protection program for the Quabbin Reservoir/Chicopee Valley Aqueduct supply is built largely on the results from more than a 100 years of extensive water quality testing and an ongoing watershed monitoring program administered by the Metropolitan District Commission, Division of Watershed Management. The various tasks of the sampling program include bi-weekly monitoring of thirty-two routine sample stations for general biological, physical and chemical water quality parameters, quarterly monitoring for select chemical constituents, and routine monthly reservoir sampling at three stations to profile general physical and chemical parameters. In CY 2000, Quabbin laboratory staff collected a total of 1,540 water samples and performed over 10,000 analytical procedures on these samples. No changes were made in either frequency or location of the thirty-seven core sampling stations that currently comprise the watershed monitoring program.

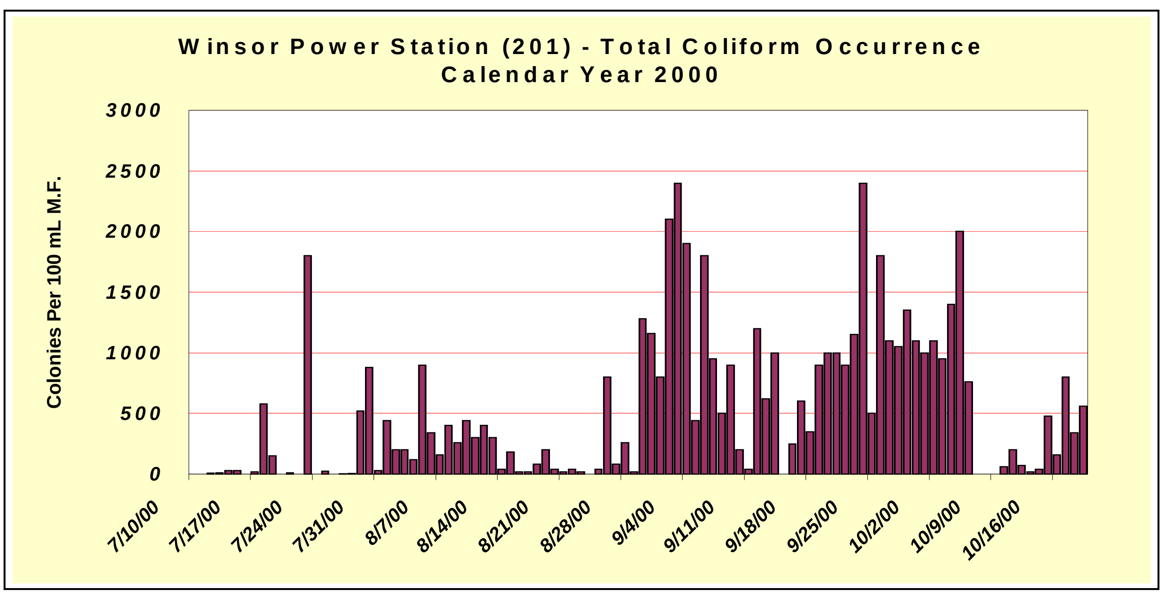
The MDC utilizes results from fecal coliform bacteria monitoring at the reservoir outlet at Winsor Dam as its primary tool for assessing SWTR compliance. In CY 2000 water samples were collected at a minimum of once daily, Monday through Thursday. Sampling was increased with an additional PM sample collected seven days a week during active phases of the ***Gull Control Program***. On July 10, 2000 the MDC laboratory began bacterial sampling and analysis for the MWRA CVA monitoring program. This arrangement also entails compliance monitoring at the 201 outlet, which demands sample collection and analysis of total and fecal coliform bacteria at a minimum frequency of five days a week. A building tap located inside the Winsor Power Station (SS #201) serves to represent water quality conditions inside of the Chicopee Valley Aqueduct prior to disinfection. A total of 385 bacteria samples were collected at the Winsor Power Station (WPS) tap in 2000. Fecal coliform bacteria was absent from more than 88% of the samples collected. At no time did fecal coliform levels exceed the SWTR standard of 20 colonies per 100 mL. Fecal coliform levels were detected at their maximum concentration of

6 colonies per 100 mL M.F. on May 25. The bacterial spike is believed to have been attributable to the presence of geese who are regular visitors to the grass lawns abutting the shore of Winsor Dam. Turbidity levels monitored weekly from the WPS tap averaged slightly below 0.3 NTU and remained stable peaking at 0.4 NTU. Summarized in Table 1 are calendar year 2000 results for selected water quality parameters monitored in Quabbin Reservoir outlets at sites 201 and 206.

From time to time special studies are initiated to cover a variety of issues and results are often used for the development of specific protection and/or treatment strategies. In CY 2000, these "special" issues included the following items introduced below:

Beginning in July and subsiding in October, total coliform levels were elevated in water samples collected from the WPS tap. Total coliform levels during this time period (July 10 through October 20) averaged 524 colonies per 100 mL and fluctuated between 0 and 2400 (see figure below). In comparison, 1999 total coliform levels averaged <2 colonies per 100 mL. Some general DWM observations made on or about the start of the period of elevated levels include:

- In routine sampling of 201 water samples fecal coliform bacteria levels were consistently absent throughout the extended period of elevated total coliform bacteria;
- Precipitation totals for the month of June at 8.43 inches ranked second among the wettest months of June on record dating back to 1939;
- Reservoir levels in June increased by 1.28 feet, representing a monthly storage gain of 10,399 million gallons;
- Similar occurrences of elevated total coliform levels were observed in reservoir samples collected at Shaft 12 in Hardwick;
- On July 10 during giardia/cryptosporidium sample collection at the WPS tap, staff noted that the filter experienced clogging, requiring much more time than usual to filter, and that filter water was more colored and turbid than usual.



DWM staff also note that bacterial dynamics of this magnitude are nothing new to Quabbin Reservoir as past water quality records allude to occurrences of this nature in the 1972-1973 period (New England Research, 1973), and more recently in the summer/fall 1998. Total coliform organisms are an umbrella group of bacteria utilized in the water supply field as an indicator of sanitary quality. The total coliform organism in itself is not pathogenic and is native to soil and decaying vegetation, making it ubiquitous in nature. In CY 2000, the MDC briefly studied its occurrence through additional in-reservoir monitoring and sought assistance from the MWRA for speciation analysis of the problem bacteria. Reasons behind the occurrences of the total coliform organisms at in-reservoir levels of this magnitude are under review at this time.

In CY 2000, researcher Elisa Garvey completed the nearly three year study of natural organic matter (NOM) concentrations occurring within Quabbin Reservoir and its contributing tributaries. NOM has been recognized since the mid 1970's an important public health consideration because of its reactivity with chlorine to form chlorinated organic compounds, some of whom have been shown to be carcinogenic in laboratory animals. Analysis of reservoir and tributary water samples was performed at the University of Massachusetts laboratory and included total and dissolved organic carbon, UV_{254} absorbance, trihalomethane formation potential (THMFP), and the apparent molecular weight distribution (AMWD). Water samples were collected monthly from the outlets of twelve Quabbin tributaires, six reservoir stations, at Shaft 12 and the CVA outlet. The objectives of the study were to characterize natural organic matter as it enters and leaves the reservoir, and, to examine relationships between the parameters and the THMFP of reservoir and tributary water. Garvey *et al*. (2000) reported several key findings of overall reservoir health that are generalized below, however, other significant findings will be eluded to later in the context of this report and the reader is urged to refer to the referenced publication for more details.

- Changes in AMWD between sources of autochthonous organic matter (i.e. that which originates from within the aquatic system) and allochthonous sources (i.e. that which are derived from the land and precipitation) indicate that the tributary inflows are not simply being diluted by reservoir volume. The authors suggested that a study of algal dynamics could shed further light on the more complex reservoir processes that alter the character of allochthonous organic matter.
- Material balance analysis indicates that Quabbin Reservoir organic matter inputs balance losses of organic matter; a trait that is reflected in long term records of apparent reservoir color and the reservoir's oligatrophic status.

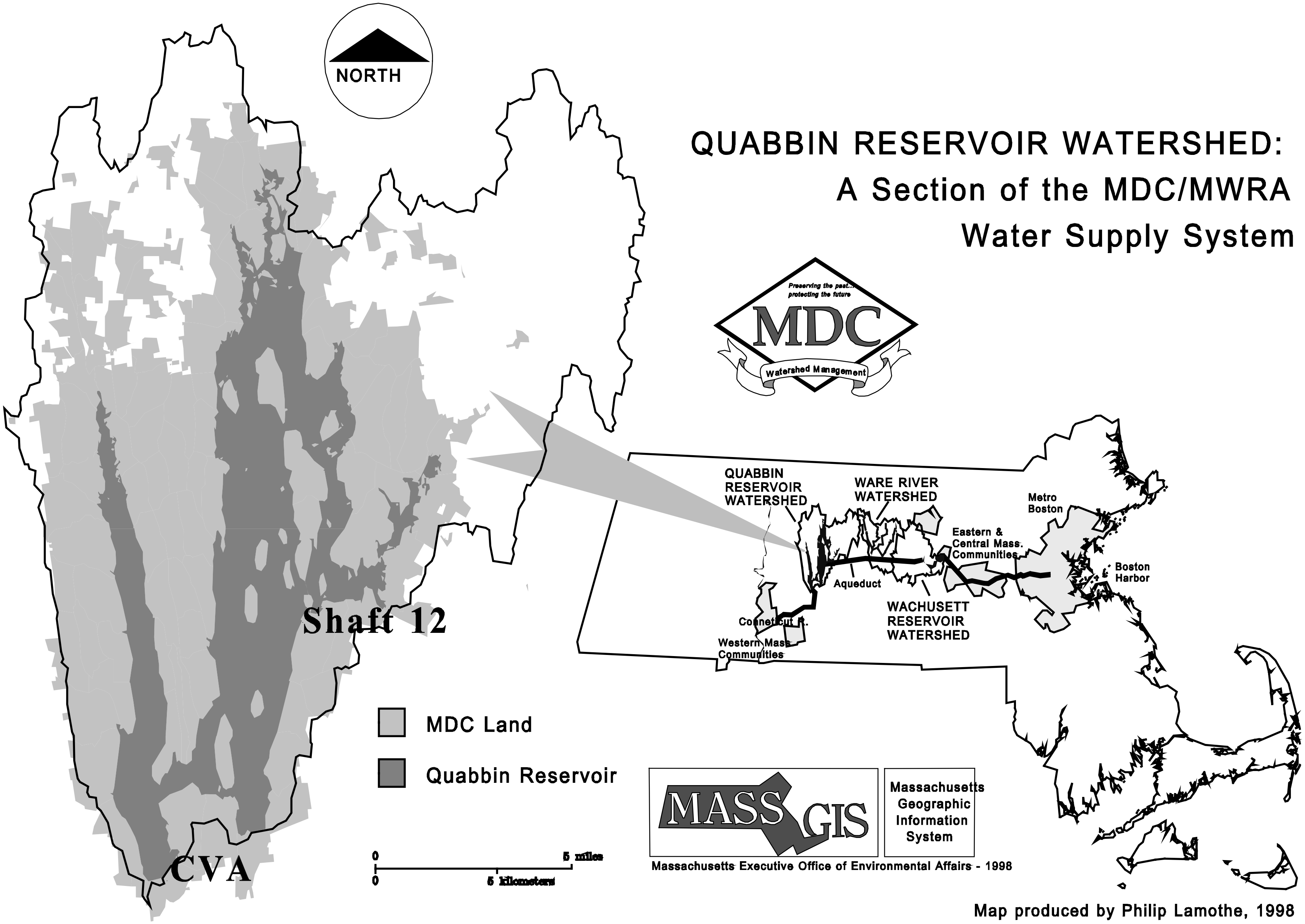
Lastly, on October 7, 2000 the MWRA transferred to the MDC laboratory responsibility of microbiological analysis of all quality assurance and Department of Environmental Protection (DEP) prescribed compliance samples collected on the Chicopee Valley Aqueduct service. The DEP requires bacterial sampling of the WPS tap at a minimum of five days per week (total and fecal) and at the Nash Hill tank (total) at least once per week. Quality assurance samples prescribed by the MWRA include a daily sample from the Ludlow Monitoring Station (total) and samples collected as often as possible from the Nash Hill tank (total). The transfer of laboratory services involved an initial quality control program whereby comparisons were made from results of duplicate samples being collected and analyzed by both the MWRA and MDC laboratory. The transfer occurred at a time when the new CVA treatment facility was placed on-line but as a whole the transition went smoothly.

The Quabbin Reservoir Water Quality Monitoring Program, briefly highlighted above, is a large-scale effort that produces a valuable wealth of information utilized for watershed management and compliance purposes. The purpose of this report is to present Calendar Year (CY) 2000 water quality results from source water monitoring performed on Quabbin Reservoir and its tributaries, including those within the Ware River watershed. The report also incorporates reservoir yield data generated by the Quabbin Civil Engineering Section and stream flow data obtained through a cooperative effort with the U.S. Geological Survey. The figures and tables presented in this report are meant simply to organize the wealth of water quality data generated annually into a meaningful format based on the source supply and its contributing tributaries. Most of the data in this report is presented separately for each sample site in tables at the end of this report. Physical and chemical data for principal Quabbin Reservoir inlets and outlets are presented in Tables 1 and 2. Similar data is presented for combined Quabbin Reservoir and Ware River tributaries in Tables 9 and 10. Information on sample site locations is presented in Tables 6 through 8 and Figures 1 through 3.

Table 1 – 2000 Quabbin Reservoir Water Quality Data: Sample Stations 201 & 206

	Parameter	Observed Range of Values				Massachusetts Water Quality Standard
		Min.	Max.	Avg.	Median	
Site 201 Winsor Power Station	***Biological***					
	Total Coliform	0	2400	220	4	No Standard
	Fecal Coliform	0	6	<1	0	H mean #20
	Physical Characteristics					
	Turbidity (NTU)	0.2	0.4	0.3	0.3	See narrative text.
	Color (units)	5	5	5	5	HH 15
	Dissolved Oxygen	85%	111%	95%	95%	H min. 75%
	Temperature	2EC	17EC	10EC	10EC	H max. #20EC
	pH (units)	6.4	6.7	6.6	6.6	H 6.5-8.3
	Alkalinity (mg/L as CaCO3)	1.9	2.8	2.6	2.6	See narrative text.
	Hardness (mg/L as $CaCO_3$)	7.8	12.0	9.1	8.2	See narrative text.
Site 206 Shaft 12 Shore	***Biological***					
	Total Coliform	0	1000	61	9	No Standard
	Fecal Coliform	0	3	<1	0	H mean #20
	Physical Characteristics					
	Turbidity (NTU)	0.2	0.5	0.3	0.3	See narrative text.
	Color (units)	5	5	5	5	HH 15
	Dissolved Oxygen	87%	110%	94%	93%	H min. 75%
	Temperature	0EC	24EC	11EC	11EC	H max. #20EC
	pH (units)	6.3	6.8	6.6	6.6	H 6.5-8.3
	Alkalinity (mg/L as CaCO3)	2.7	4.3	4.0	4.0	See narrative text.
	Hardness (mg/L as $CaCO_3$)	7.5	17.9	10.5	8.2	See narrative text.

Notes:
H *MA Inland Class A Water Body Standards* - Minimum criteria established for surface waters to sustain and protect them from the degradation of their designated use(s). HH*MA Secondary Drinking Water Standards* - Used in the absence of available raw water quality standards. These standards are meant to serve as a guide, the parameters are not known to cause a health risk but may affect the taste, odor and color of water.
1.) Coliform concentration reported as number of colonies per 100 mL.
2.) PPM - Parts per million, equivalent to one drop in 10 gallons.


QUABBIN RESERVOIR WATERSHED:
A Section of the MDC/MWRA
Water Supply System
NORTH
Preserving the past... protecting the future
MDC
Watershed Management
Shaft 12
CVA
MDC Land
Quabbin Reservoir
0 5 miles
0 5 kilometers
QUABBIN RESERVOIR WATERSHED
WARE RIVER WATERSHED
Metro Boston
Eastern & Central Mass. Communities
Boston Harbor
Aqueduct
WACHUSETT RESERVOIR WATERSHED
Connecticut R.
Western Mass Communities
MASS GIS
Massachusetts Geographic Information System
Massachusetts Executive Office of Environmental Affairs - 1998
Map produced by Philip Lamothe, 1998

1.0 CHARACTERIZATION OF THE QUABBIN RESERVOIR WATERSHED SYSTEM

Chapter 372 of the Acts of 1984 established the Metropolitan District Commission, Division of Watershed Management and directed the Division to manage and maintain a system of watersheds and reservoirs in order that pure water could be provided to the Massachusetts Water Resources Authority (MWRA). The MWRA in turn was created as in independent agency whose chief responsibility was the delivery and distribution of drinking water to approximately 2.5 million people across Massachusetts.

Figure 1 shows the Quabbin Reservoir, Ware River and Wachusett Reservoir watershed system that supplies drinking water to Boston and 46 other member communities that make up the MWRA service territory. The largest of the three interconnected sources is Quabbin Reservoir, a 412 billion gallon impoundment of the Swift River located in Central Massachusetts. Quabbin Reservoir transfers to Wachusett Reservoir via the Quabbin Aqueduct Intake at Shaft 12 typically account for more than half of MWRA's system supply. Quabbin Reservoir also supplies a much smaller amount of water directly to three western Massachusetts communities via the Chicopee Valley Aqueduct (CVA). Water is delivered via two, gravity fed aqueduct systems whose intake structures are labeled in Figure 1. The Quabbin Aqueduct intake at Shaft 12 is located along Quabbin Reservoir's eastern shoreline in Hardwick. The CVA intake lies at the base of Winsor Dam in Belchertown. MDC has maintained a SWTR filtration waiver status for its CVA supply since 1992. The filtration waiver for the Wachusett Reservoir was challenged in federal court in a case initiated by the Federal Environmental Protection Agency. The initial findings in support of the MWRA's case for filtration avoidance were appealed by the EPA and no decision has been issued by the time of the printing of this report. The focus of this report is the Quabbin Reservoir watershed and supplemental supplies from Ware River diversions. Land use characteristics of the contributing watersheds are summarized below.

Quabbin Reservoir watershed is about 19 miles long, 13 miles wide, and contains roughly 120,000 acres. More than 90% of watershed lands are forested and the Metropolitan District Commission owns and controls 53,000 acres (55%) for water supply protection. The majority of non-MDC owned land is maintained as private forest. Developed lands can be characterized as sparsely populated and having limited agricultural sites.

The Ware River watershed is about 11 miles long, 7 miles wide, and contains roughly 62,000 acres. Nearly 75% of the watershed is forested and the Metropolitan District Commission owns and controls 22,000 acres (35%) for water supply protection. The vast majority of private lands are maintained as forests and developed lands consist primarily of low density residential and agricultural sites. Waters from Ware River are diverted into the Quabbin Aqueduct at Shaft 8 in Barre and directed west towards Quabbin via gravity flow. Ware River flows enter the reservoir at Shaft 11A located east of the baffle dams in Hardwick. Diversions are limited to periods when Ware River flows exceed 85 MGD and require DEP approval unless conducted during the allowable diversion period from October 15 to June 15.

Table 2 – 2000 Ware River Water Quality Data: Shaft 8						
	Parameter	Observed Range of Values				Massachusetts Water Quality Standard
		Min.	Max.	Avg.	Median	
2000 DATA IN WHOLE	***Biological***					
	Total Coliform	50	1300	351	300	No Standard
	Fecal Coliform	0	200	31	17	H mean #20
	Physical Characteristics					
	Turbidity (NTU)	0.5	2.5	1.28	0.95	See narrative text.
	Color (units)	42	140	79	68	HH 15
	Dissolved Oxygen	89%	103%	94%	94%	H min. 75%
	Temperature	0EC	22EC	9.8EC	9.0EC	H max. #20EC
	pH (units)	5.8	6.7	6.3	6.3	H 6.5-8.3
	Alkalinity (mg/L as CaCO3)	2.3	8.4	5.1	5.35	See narrative text.
	Specific Conductance (micromhos per cm)	52	122	72	69	See narrative text.
DURING ALLOWABLE DIVERSION PERIOD OCT 15 THRU JUN 15	***Biological***					
	Total Coliform	50	1300	350	300	No Standard
	Fecal Coliform	0	80	28	7	H mean #20
	Physical Characteristics					
	Turbidity (NTU)	0.5	2.2	1.67	0.8	See narrative text.
	Color (units)	42	75	68.9	60	HH 15
	Dissolved Oxygen	89%	103%	93%	94%	H min. 75%
	Temperature	0EC	19EC	8.7EC	3EC	H max. #20EC
	pH (units)	5.8	6.5	6.65	6.2	H 6.5-8.3
	Alkalinity (mg/L as CaCO3)	2.3	5.9	5.2	4.4	See narrative text.
	Specific Conductance (micromhos per cm)	52	122	72	72	See narrative text.

Notes:
H *MA Inland Class A Water Body Standards* - Minimum criteria established for surface waters to sustain and protect them from the degradation of their designated use(s).
HH*MA Secondary Drinking Water Standards* - Used in the absence of available raw water quality standards. These standards are meant to serve as a guide, the parameters are not known to cause a health risk but may affect the taste, odor and color of water.

In CY 2000, Ware River water was diverted over a span of six days totaling 603.8 million gallons. In biweekly monitoring (happening once every two weeks) conducted downstream of the Shat 8 intake works facility, fecal coliform levels were recorded at a maximum of 200 colonies per 100 mL M.F. on July 17th. Turbidity levels monitored bi-weekly exceeded 1 NTU in 12 of 26 grab samples collected. Table 2 exhibits the notable improvement in water quality observed during the allowable diversion period. In particular, fecal coliform levels averaged slightly below 15 colonies per 100 mL M.F. and turbidity levels exceeded 1 NTU in 4 of 17 grab samples collected. At no time were turbidity levels recorded above 5 NTU.

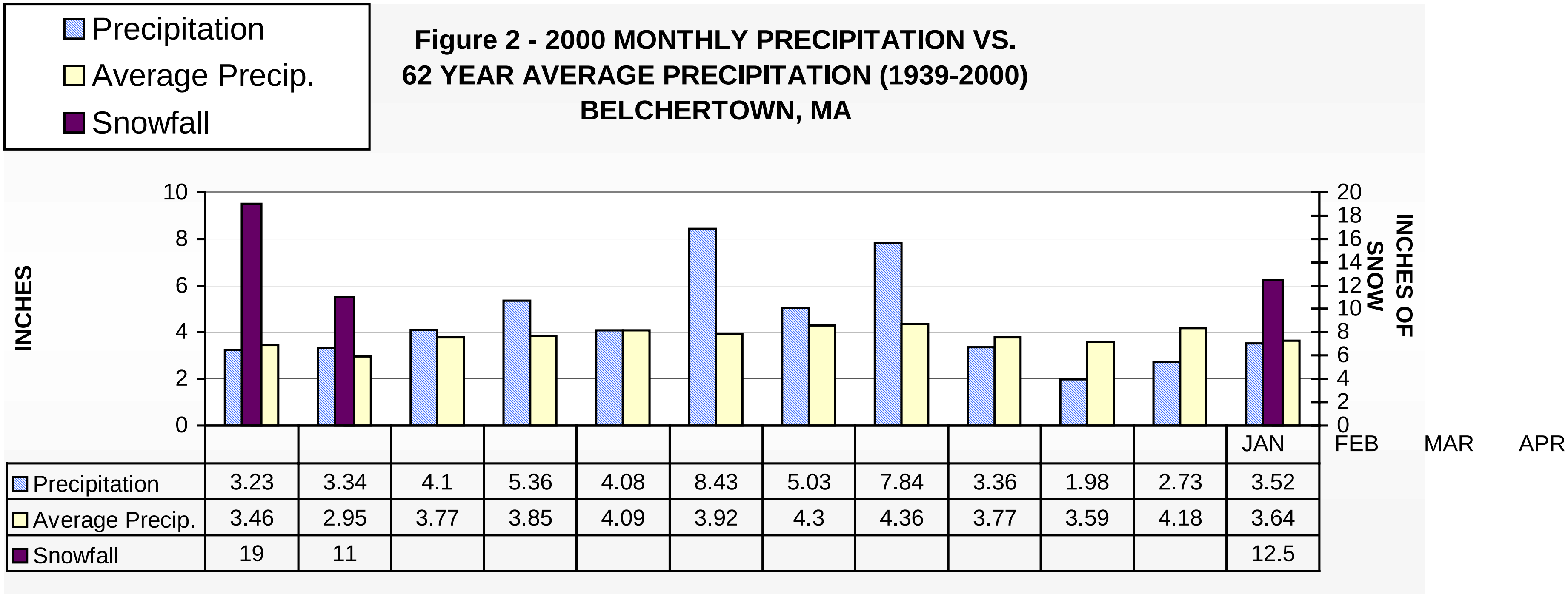
No wastewater treatment plant discharges are currently permitted in tributaries to either of the three water supplies. Industrial and commercial sites throughout the three watersheds are limited.

PRECIPITATION

For more than seventy years, the Metropolitan District Commission has collected and maintained weather station data for the primary purpose of determining reservoir yields. Table 3 summarizes monthly precipitation totals for records dating back to 1930 for the Belchertown station weather station. Annual precipitation totals have averaged 45.90 inches and monthly precipitation totals average between 2.95 and 4.36 inches (months of February and August respectively).

In 2000, the precipitation total of 53.0 inches took over the number eleven spot in the ranking of the wettest years in the 62-years of record keeping at the Belchertown meteorological station. Monthly precipitation totals were within a normal range of conditions for the months of January, February, March, May, July, September, November and December. Notably wet months with totals ranking above 80 percentile of all records for that month included April, June and August. October was the only "dry" month with totals falling below the 20th percentile ranking of recorded values. Throughout the year fourteen storm events exceeded one inch in a 24 hour period and one of these, occurring on August 11, exceeded 5 inches (typically regarded as a twenty five year recurrence interval). The seasonal (i.e. November 1999 through April 2000) snowfall total of 30.0 inches fell below the seasonal average of 48.21 inches. Figure 2 illustrates the distribution of precipitation in calendar year 2000.

**Figure 2 - 2000 MONTHLY PRECIPITATION VS.
62 YEAR AVERAGE PRECIPITATION (1939-2000)
BELCHERTOWN, MA**



Precipitation	3.23	3.34	4.1	5.36	4.08	8.43	5.03	7.84	3.36	1.98	2.73	3.52
Average Precip.	3.46	2.95	3.77	3.85	4.09	3.92	4.3	4.36	3.77	3.59	4.18	3.64
Snowfall	19	11										12.5

Table 3.
Monthly Precipitation (inches) Statistics for Belchertown Meteorological Station: 1939 – 2000

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	Totals
average	3.46	2.95	3.77	3.85	4.09	3.92	4.30	4.36	3.77	3.59	4.18	3.64	45.90
minimum	0.70	0.48	0.55	0.87	0.90	1.10	0.84	0.89	0.86	0.56	0.93	0.76	29.70
maximum	10.21	7.03	7.58	9.11	13.09	9.62	9.45	22.96	11.55	11.08	7.32	8.19	64.92
20 percent exceedance	4.87	3.84	5.06	5.25	5.43	4.91	5.73	5.94	6.30	5.19	5.78	5.14	51.39
80 percent exceedance	1.98	2.09	2.48	2.21	2.75	2.47	2.68	1.96	1.86	2.05	2.76	2.24	40.47
Percent exceedance means that 80 or 20 percent of all monthly totals for the given time period have been greater than the value shown.													

Source: MDC Quabbin Civil Engineering Section

STREAM FLOWS

Through a cooperative agreement with the United States Geological Survey (USGS), five stream gauges are actively being monitored and these include the Ware River in Barre (at intake), Ware River at Barre Falls, East Branch Swift in Hardwick, West Branch Swift in Shutesbury, and the Swift River below Winsor Dam. Locations of the stream gauging stations are depicted in the Figure 3 and Appendix A contains daily mean discharge data for the 2000 Water Year (beginning on October 1, 1999 and ending September 30, 2000). In WY 2000, all stations maintained at or above average monthly stream discharges throughout the year. New maximum monthly mean discharges were set for the station on the West Branch Swift River for the months of October and August. The highest mean daily flow for the West Branch Swift was calculated at 313 cubic feet per second (cfs) and was recorded on June 6, 2000. The East Branch Swift River and Ware River in Barre had peak mean daily flows that occurred three days apart from one another in April 2000. Daily mean flows in the East Branch Swift peaked on April 26 at 450 cfs and flows in the Ware River peaked on April 29 at 882 cfs. Flow in the Swift River near Ware is primarily controlled through controlled releases from Winsor Dam, as reflected in the small variation in monthly mean flows. The peak mean daily flow was measured at 114 cfs on September 6, 2000, during a time of moderately dry weather . The moderately dry weather was characterized by 1.13 inches of rain occurring over a 27 day span, beginning on August 17 and ending September 12. Coincidentally, minimum daily mean flows for each of the three tributary stations were recorded on the same day, September 12, 2000.

RESERVOIR CONDITIONS

Reservoir storage capacity began the year at 86.1% and ended at 91.1% reflective of the above normal yearly precipitation total. The reservoir delivered an average of 7.69 million gallons per day (MGD) to the Chicopee Valley Aqueduct service area over the course of 366 days. During the 233 days that water was released to Wachusett Reservoir, flow entering the Quabbin Aqueduct averaged 183.3 MGD. A total of 474.6 million gallons (MG) was discharged over the spillway over the course of 46 days beginning on June 11 and ending July 19, then beginning again on August 11 before ending on August 17. A total of 603.8 million gallons of water was diverted from Ware River over the course of six days at the end of March.

Ice covered the reservoir for an extended period of 48 days beginning on January 24 and ending March 12. In four snow surveys performed between February 7 and February 28, average watershed snow depths ranged from 4.86 to 13.99 inches. In sharp contrast, no snow surveys were performed in 1999 due to the lack of snowfall (Source: MDC Civil Engineering Records, unpublished).

Figure 3. Locations of USGS Stream Gaging Stations Quabbin Reservoir Watershed

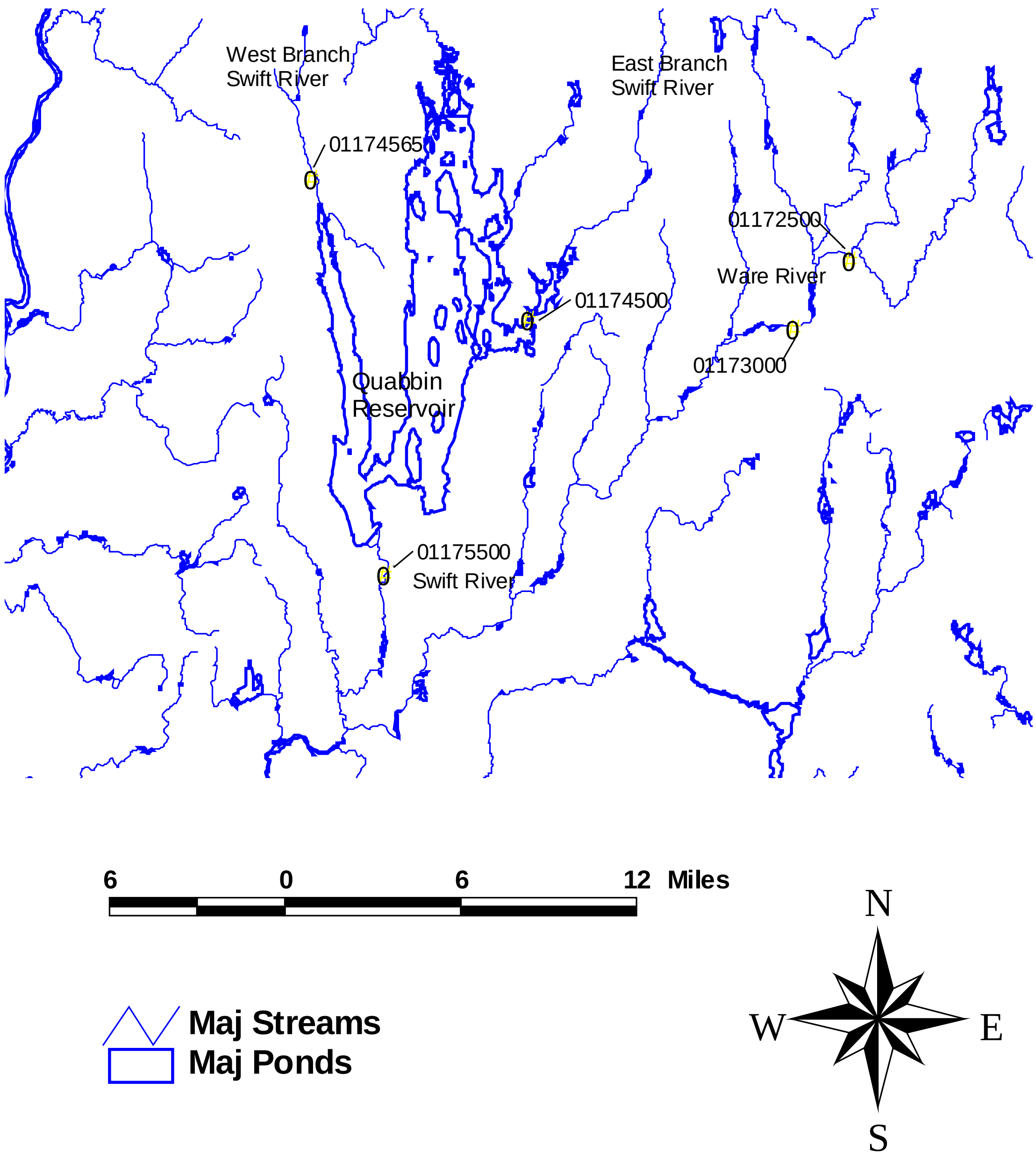


TABLE 5
QUABBIN RESERVOIR FACTS AND FIGURES – Calendar Year 2000

FACTS ABOUT THE RESERVOIR		FACTS ABOUT THE WATERSHED	
Capacity	412 Billion Gals	**Watershed Area**	120,000 acres
Surface Area	24,000 acres	**Land Area**	96,000 acres
Length of Shore	118 miles	**MDC Owned Land**	53,000 acres
Maximum Depth	150 feet	**% MDC Owned**	55%
Mean Depth	45 feet	**Forested Lands**	83,235 acres
Surface Elevation	530 feet	**Wetlands**	5,289 acres
Year Construction Completed	1939	**Avg. Reservoir Gain From 1" of Precipitation**	1.6 Billion Gallons
CY 2000 statistics			
2000 Maximum Reservoir Elevation (ft)	528.62 on June 28	**Total Diversions to CVA**	2,816.4 MG (avg. 7.69 MGD)
2000 Minimum Reservoir Elevation (ft)	522.40 on February 11 & 13	**Total Diversions to Wachusett Reservoir**	42,708.7 MG (233 days)
Reservoir Ice Cover	100% cover: January 24 through March 12.	**Total Diversions to Swift River**	9,324 MG
Ware River Diversions	603.8 MG (3/21-3/24 & 3/27-3/28)	**Spillway Discharges**	474.6 MG (6/11-7/19 & 8/11-8/17)

2.0 WATER QUALITY SAMPLING PROGRAM

For nearly 100 years, the MDC and its predecessors have been collecting water quality data to characterize the quality of water entering and leaving the Swift River valley. Figures 3 and 4 display the thirty-six, active monitoring stations that are comprised of twenty streams, seven ponds and five reservoir stations established in the Quabbin Reservoir watershed. The purpose of the monitoring program is to: assess compliance with Massachusetts drinking water standards for source water supplies; track overall health of the system; determine tributary compliance with Massachusetts surface water standards; and, to establish a foundation of data from which potential management strategies may be determined.

Tributary stations are monitored biweekly (happening once every two weeks) and entails grab sample collection at the start of each week. Samples are collected regardless of weather conditions thereby providing a good representation of various flow conditions and pollutant loadings. Temperature and dissolved oxygen are determined in the field using a YSI Model 57 dissolved oxygen meter. Water samples are analyzed at the MDC Quabbin laboratory for total and fecal coliform, alkalinity, pH, specific conductance and turbidity. Analysis is also performed quarterly for color, chloride, hardness and iron. Total and fixed solid analysis was discontinued.

QUABBIN LABORATORY: FIELD AND LABORATORY METHODS

PARAMETER	STANDARD METHOD
Turbidity	SM 2130 B
pH	SM 4500-H
	Hydrolab Data Sonde 4a, Orion 811 meter
Alkalinity	SM 2320 B (low level)
Chloride	SM 4500-Cl C
Hardness	SM 2340 C
Color	SM 2120 B
Conductivity	HACH DREL/5 meter
	Hydrolab Data Sonde 4a
Temperature	YSI Model 57 DO Meter
	Hydrolab Data Sonde 4a
Dissolved Oxygen	YSI Model 57 DO Meter
	Hydrolab Data Sonde 4a
Iron	HACH DR/3 Spectrophotometer
Total Coliform	SM 9222B
Fecal Coliform	SM 9222

[1]Daily - Constitutes AM collection Monday through Thursday. Sampling is increased with an additional PM sample collected seven days a week during phases of the *Gull Control Program.*

MDC staff monitor temporal variations of reservoir water quality at stations established inside of three distinct reservoir basins: the West Arm at Winsor Dam; the Central Basin at Shaft 12; and, the East Arm at Den Hill. In 2000, a fourth site A2 located east of the "pass" in the East Arm was added to compliment University of Massachusetts research objectives. The reservoir sites were monitored monthly between March and December. Staff utilized a Hydrolab Data Sonde 4a field instrument (new this year) to determine reservoir depth profiles of temperature, pH, dissolved oxygen, and specific conductance. A kemmerer bottle is used to collect water samples at mid-epilimnion and mid-hypolimnion (or at 0.5 meter and 1 meter off bottom during thermal uniformity) for analysis of turbidity, color, chloride, hardness, and alkalinity. A grab water sample analyzed for coliform bacteria is also collected at the surface and a secchi disk is used to record transparency.

The quality of water entering the two reservoir aqueducts is aggressively monitored by the MDC. Water entering the CVA is monitored for coliform bacteria on a daily[1] basis and each week the same physical and chemical constituents as performed on the tributaries is monitored at the CVA. A building tap located inside the Winsor Power Station, sample site 201, serves to represent water being withdrawn from approximately 70 feet below the surface of the reservoir. Sample site 206 is located at the shore of the Shaft 12 intake works facility. At this location grab samples are collected weekly from just below the surface of the reservoir and are analyzed for the same physical and chemical parameters as those studied in the tributaries.

In CY 2000, MDC laboratory staff formalized a Quality Assurance Plan that outlines a standardized set of operating and quality assurance procedures. Quality control records are maintained inside the Quabbin Laboratory on permanent bound books.

Table 6 – 2000 Quabbin Reservoir Sample Stations

Station	Location	Universal Transverse Mercator (UTM) Coordinates*	Frequency
(201) Winsor Power Station	Building tap located on Chicopee Valley Aqueduct prior to disinfection.	130448.40, 892497.60	Daily – Constitutes AM collection Monday through Thursday. Sampling is increased with an additional PM sample collected seven days a week during phases of the *Gull Control Program.*
(206) Shaft 12 shoreline	Shoreline beside Shaft 12 intake building	135866.90, 902601.20	Weekly
Shaft 11A	Quabbin Aqueduct outlet on Quabbin shoreline, east of baffle dams.	139244.40, 902997.10	Weekly during Ware River diversions.
QR01/202 CVA Intake	Quabbin west arm off of Winsor Dam	129908.40, 893432.60	Monthly**
QR06/206	At site of old Quabbin Lake, off shore of Shaft 12	135308.80, 902472.80	Monthly**
QR10/Den Hill	North of Den Hill	136910.90, 904555.50	Monthly**

UTM coordinates referenced using NAD 27. In 1999, depth and temperature profiles were determined at these sites during the months of April through December.

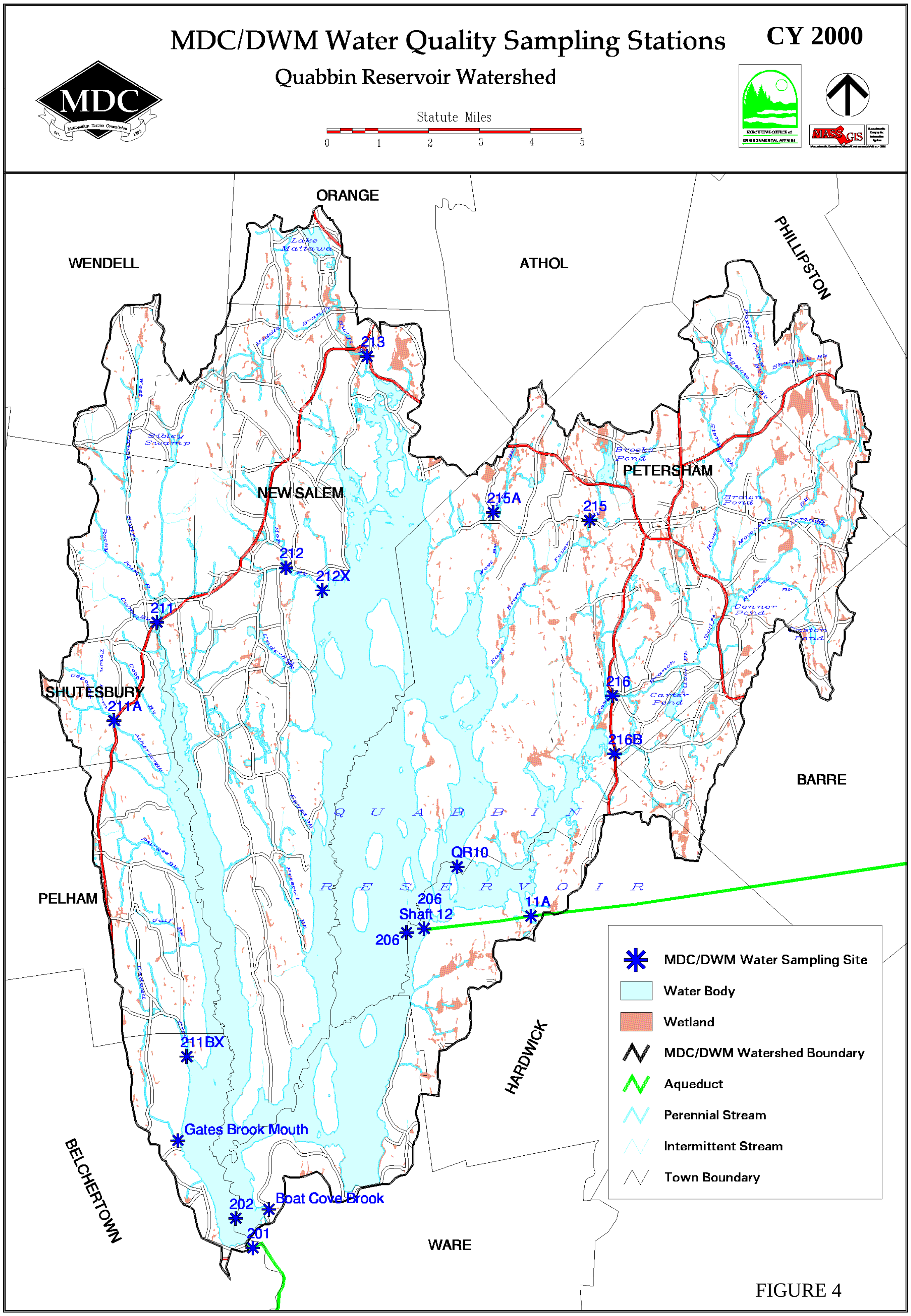

MDC/DWM Water Quality Sampling Stations
CY 2000
Quabbin Reservoir Watershed
MDC
Statute Miles
0 1 2 3 4 5
ORANGE
WENDELL
ATHOL
PHILLIPSTON
NEW SALEM
PETERSHAM
SHUTESBURY
BARRE
PELHAM
HARDWICK
BELCHERTOWN
WARE
Q U A B B I N
R E S E R V O I R
213
212
212X
211
211A
215A
215
216
216B
QR10
206
Shaft 12
11A
211BX
Gates Brook Mouth
202
Boat Cove Brook
201
MDC/DWM Water Sampling Site
Water Body
Wetland
MDC/DWM Watershed Boundary
Aqueduct
Perennial Stream
Intermittent Stream
Town Boundary

FIGURE 4

Table 7

Quabbin Reservoir Tributaries: 2000 Sampling Stations

Tributary	Sample Site #	*Sample Frequency*[1]	*Basin Characteristics* Drainage Area (sq. miles)[2]	% Wetland Coverage[3]	% MDC Owned Land[4]
East Br. of Swift River @ Rt. 32A	216	BW	30.3	10.4%	1.7%
West Br. of Swift River @ Rt. 202	211	BW	12.4	3.4%	33.0%
Middle Br. of Swift River @ Gate #30	213	BW	9.14	8.1%	22.7%
East Br. of Fever Brook @ West Road	215	BW	4.15	11.5%	12.3%
West Br. of Fever Brook @ Womens Fed.	215A	BW	2.69	8.9%	18.4%
Hop Brook @ mouth	212-X	BW	5.43	2.7%	44.8%
Hop Brook @ Gate 22	212	BW	4.52	2.5%	32.0%
Rand Brook @ Rt. 32A	216B	BW	2.42	9.9%	22.7%
Atherton Brook @Rt. 202	211A	BW	1.83	3.2%	36.0%
Cadwell Creek @ mouth	211BX	BW	2.59	3.3%	98.0%
Gates Brook @ mouth	Gates	BW	0.93	3.2%	100.0%
Boat Cove Brook @ mouth	BC	BW	0.15	<<1%	100.0%

Notes:
[1]BW = biweekly meaning happening once every two weeks. Prior to May 1990 tributaries were monitored on a weekly basis.
[2]Source: Massachusetts Geographic Information System, Executive Office of Environmental Affairs. Latest revision 3/90.
[3]Source: DEP Wetland Conservancy Program (interpreted from 1:12000 Spring 1992-93 photos, latest revision 4/96).
[4]Source: Automated by Massachusetts Geographic Information System & MDC, latest revision 6/97.

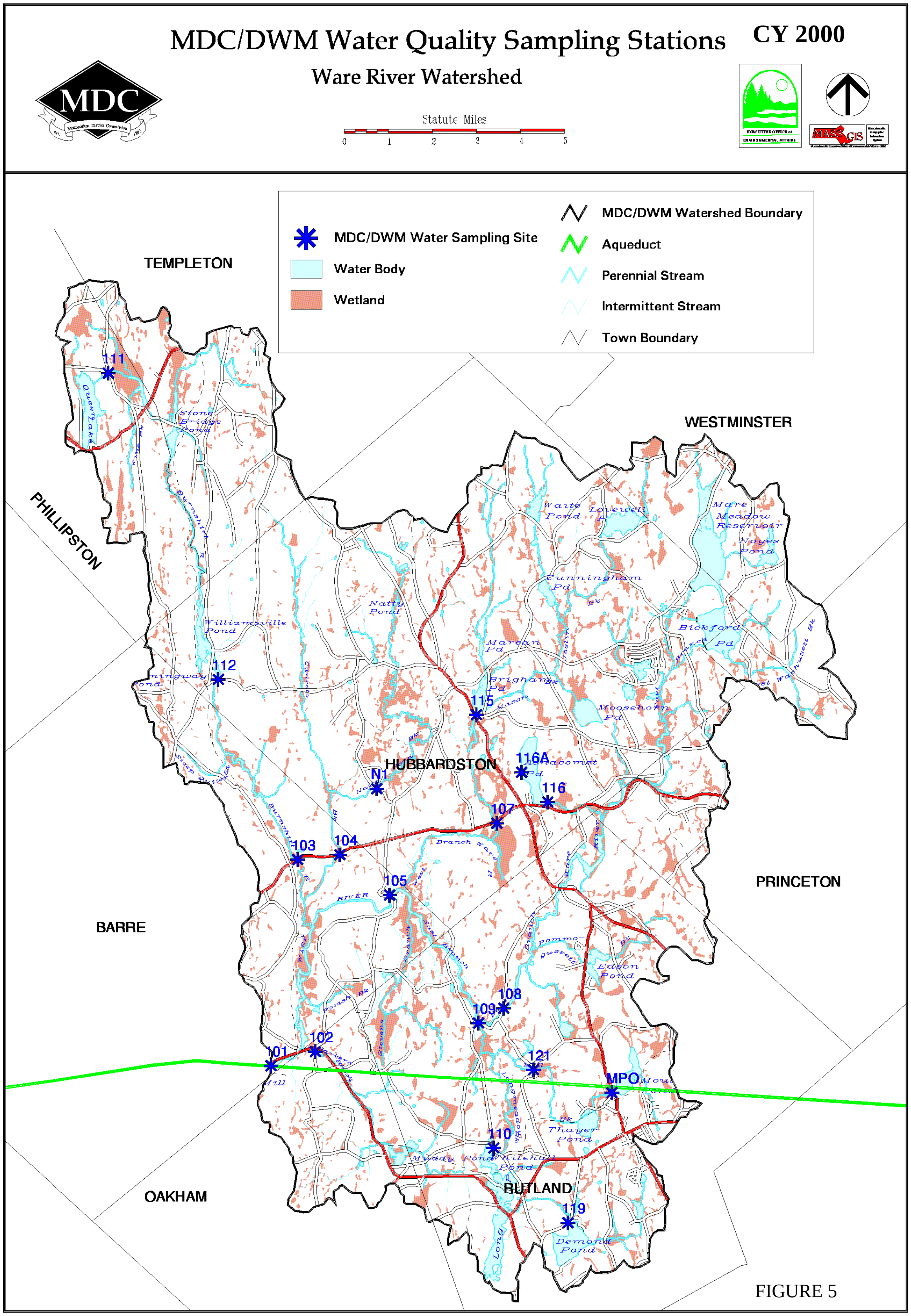

MDC/DWM Water Quality Sampling Stations
CY 2000
Ware River Watershed
MDC
Statute Miles
0 1 2 3 4 5
MDC/DWM Water Sampling Site
Water Body
Wetland
MDC/DWM Watershed Boundary
Aqueduct
Perennial Stream
Intermittent Stream
Town Boundary
TEMPLETON
WESTMINSTER
PHILLIPSTON
HUBBARDSTON
PRINCETON
BARRE
OAKHAM
RUTLAND
111
112
115
116A
116
N1
107
103
104
105
108
109
102
101
121
MPO
110
119
Stone Bridge Pond
Williamsville Pond
Natty Pond
Waite Pond
Lovewell P
Mare Meadow Reservoir
Noyes Pond
Cunningham Pd
Bickford Pd
Moosehorn Pd
Brigham Pd
Comet Pd
Edson Pond
Thayer Pond
Demond Pond
Long Pond
RIVER
FIGURE 5

Table 8

Ware River Tributaries: 2000 Sampling Stations

Tributary	Sample Site #	Sample Frequency[1]	*Basin Characteristics* Drainage Area (sq. miles)[2]	% Wetland Coverage[3]	% MDC Owned Land[4]
Ware River @ Shaft 8 (intake)	101	BW	96.5	13.2%	37.1%
Burnshirt River @ Rt. 62	103	BW	18.4	11.7%	23.5%
Cannesto/Natty @ Rt. 62	104	BW	12.7	8.7%	28.0%
Ware River @ Barre Falls	105	BW	55.1	15.6%	34.5%
Parker Brook @ mouth	102	BW	4.9	9.6%	82.7%
West Branch Ware @ Rt. 62	107	BW	16.6	15.1%	44.9%
East Branch Ware @ New Boston Rd.	108	BW	22.0	16.5%	12.3%
Longmeadow Brook @ mouth	109	BW	12.2	16.5%	47.8%
Long and Whitehall Pond @ outlet	110	BW	5.4	17.8%	37.7%
Queen Lake @ road culvert	111	BW	0.7	36.8%	0%
Burnshirt River @ Williamsville Pond	112	BW	11.4	14.5%	2.5%
Natty Pond Brook @ Hale Road	N1	BW	5.5	14.0%	33.2%
Moulton Pond @ outlet	Moult Pd	BW	1.7	16.4	2.0
Brigham Pond @ outlet	115	BW	11.4	15.4	37.4
Asnacomet Pond @ outlet	116	BW	0.8	29.8	20.9
Demond Pond @ outlet	119	BW	2.3	18.2	14.2
Mill Brook @ Charnock Hill Road	121	BW	3.5	15.5	13.1

Notes:
[1]BW = biweekly meaning happening once every two weeks. Prior to May 1990 tributaries were monitored on a monthly basis.
[2]Source: Massachusetts Geographic Information System, Executive Office of Environmental Affairs. Latest revision 3/90.
[3]Source: DEP Wetland Conservancy Program (interpreted from 1:12000 Spring 1992-93 photos, latest revision 4/96).
[4]Source: Automated by Massachusetts Geographic Information System & MDC, latest revision 6/97.

3.0 WATER QUALITY DATA

Water quality data for individual sample stations can be found in Appendix D of this report. Tables 10a and 10b list for each watershed, the parameters monitored with ranges of minimum and maximum, average, and median concentrations. Each parameter being routinely monitored in watershed tributaries is briefly described below. Information in this section was referenced from the Massachusetts Surface Water Quality Standards, Standard Methods for the Examination of Water and Wastewater, 20th Ed., Principles of Water Quality (1984) and USEPA's 1986 Quality Criteria for Water.

Biological

Fecal Coliform Bacteria

Fecal coliform bacteria are used as possible indicators of fecal matter contamination because they are normal inhabitants of the intestinal tract of man and other animals. Levels can vary greatly depending upon pollutant inputs, stream temperatures, precipitation inputs and stream flows. Geldreich and Kenner (1969) reported bacterial densities (# fecal colonies per gram of feces shed) for cows and humans to be in the range of 230,000 to 13,000,000 respectively. The Massachusetts Class A, inland water standard for fecal coliform is an arithmetic mean of #20/100mL, and, no more than 10% of representative samples shall exceed 100/100mL. If the tributaries were ranked using annual median values of fecal coliform bacteria, Ware River at Barre Falls, East Branch Ware River at New Boston Road, and the Demond Pond Outlet would rank as the top three impacted reaches. Among the Quabbin tributaries, the East Branch Swift ranks highest at a median of 11 colonies per 100 mL, eighth ranking overall. Table 9 compares median values of selected tributaries that ranked among the highest of impacted streams.

Total Coliform Bacteria

Total coliform organisms are the umbrella group of bacteria utilized in the water supply field as an indicator of sanitary quality. The total coliform organism in itself is not pathogenic and is native to soil and decaying vegetation, making it ubiquitous in nature. Others (i.e. Geldreich, 1968) have concluded little sanitary significance of environmental monitoring for these organisms citing the fact that the total coliform group is comprised mainly of the aerogenes group that is of non-fecal origin and ubiquitous in nature. Moreover, there has been much debate as to whether or not total coliform organisms can multiply (i.e. experience aftergrowths) inside the stream environment (Streeter, 1934), casting further doubt on the qualitative assessment of the numbers. Nevertheless, the continued reliance upon the total coliform group for regulatory compliance in finished water shows its utility in assessing the efficiency of water quality treatment operations and distribution system integrity.

Table 9
Selected Quabbin Reservoir and Ware River Tributaries
Median Ranking of Fecal Coliform Data CY 2000[1]

Tributary	Drainage Area (sq miles)	Fecal Coliform Colonies Per 100 mL M.F.					
		Median	Ranking	Average	Std. Dev	%∃20	%∃100
Ware River @ Barre Falls	55.1	36	1	51	50.9	60.0%	20.0%
East Branch Ware @ New Boston	22.0	30	2	37	40.6	57.7%	7.7%
Demond Pond @ Outlet	2.3	25	3	29	32.9	52.0%	4.0%
Ware River at Shaft 8	96.5	17	4	31	44.9	34.6%	7.7%
Canesto & Natty Brook	12.7	15	5	27	37.6	42.3%	7.7%
Queen Lake @ Rd. Culvert	0.7	13	7	50	75.5	42.9%	14.3%
East Br. of Swift River @ Rt. 32A	30.3	11	8	25	35.5	34.6%	7.7%
Middle Br. of Swift River @ Gate 30	9.14	10	9	25	42.9	30.8	3.9%

[1]Source: MDC Quabbin Laboratory Records. Note that fecal coliform has been monitored in Quabbin Reservoir tributaries on a bi-weekly basis since May 1990. Tributary inflows estimated

Physical and Chemical Characteristics

<u>% Wetlands</u>
The percent wetland cover was estimated using land use classification data obtained from the MDC/MWRA Landuse Program, which interpreted Spring 1992-93 aerial photography. Several researchers that include Surballe (1992) and Lent et. al. (1998) have illustrated the significance of these land use types on the effects of overall composition of water quality in the Quabbin Reservoir watershed. Most recently, Garvey et al (2000) alluded to the statistical significance of east versus west gradients observed in tributary concentrations of total organic carbon, UV absorbance, THMFP, and the nutrient nitrogen and phosphorous. The observed gradient was explained by echoing previous findings relating the significance of wetland composition in stream chemistry.

<u>Turbidity</u>
Turbidity is the relative measure of the amount of light refracting and absorbing particles suspended in the water column. Turbidity is used as an indicator of water aesthetics and as a relative measure of the water's productivity. Excessive turbidity can interfere with treatment efficiency and may be harmful

to aquatic species. The drinking water standard is 5 NTU for source water and 1 NTU for finished water.

Color

Particulate matter such as decaying organics and certain inorganic materials causes color. Color is an important characteristic because it is an indication of humic content and , therefore, of dissolved organics. Organic compounds are a concern because there is the potential of forming carcinogenic compounds when reacted with chlorine disinfectant.

Dissolved Oxygen

Aquatic life depends on oxygen dissolved in water for its survival. Oxygen levels are depleted through the oxygen requirements of aquatic life, the decomposition of organic matter and the introduction of foreign oxygen-demanding substances. Stream flow, turbulence, depth and other physical characteristics of the stream principally drive reaeration. The Massachusetts Class A, inland water standard is a minimum of 6.0 mg/L for cold water fisheries. Most higher life forms require a minimum of about 2 mg/L of dissolved oxygen and game fish typically require at least 4 mg/L.

Temperature

In 2000, stream temperatures ranged from 0 to 26 degrees Celsius among all trinutaries combined. The Massachusetts Class A, inland water standard for a cold-water fishery is a maximum of 20EC.

pH

The pH is the measure of the water=s reactive characteristics. A drop in pH by one unit represents a ten-fold increase in acidity. The lower the pH the more likely the water will dissolve metals and other substances. A value of 7 indicates neutral water. pH is also an important factor in the solubility of persistent heavy metals such as mercury. At pH levels below 6, soluble methyl mercury remains incorporated in the water system and can be more readily accumulated in the tissue of living organisms. The standard specified for Massachusetts Class A, inland water ranges from 6.5 to 8.3.

Alkalinity

Alkalinity is a relative measure of water's ability to neutralize acidic inputs, and thus is a measure of a waterbodies defense against acidification. The Massachusetts Acid Rain Monitoring project utilizes alkalinity to categorize and rank sensitivity of waters to impacts from acid rain. Sensitivity criteria ranges from 0 to 20 mg/L of alkalinity with zero categorized as acidified and 10-20 as sensitive. Nearly ¾ of all sampling results combined (includes both Quabbin and Ware River tributaries), are divided evenly among the endangered and highly sensitive ARM rankings.

Hardness

Hardness is principally an indirect measure of the calcium and magnesium ions present in water. In general, water containing less than 50 mg/L as CaCO3 is considered soft and corrosive. In conventional water treatment, A hard water has been shown to play a significant role in preventing the leaching of potentially toxic metal ions such as lead, cadmium and zinc from bounded, insoluble complexes.

Table 10a – 2000 Tributary Water Quality Data: Quabbin Reservoir Watershed

Parameter	Observed Range of Values				Massachusetts Water Quality Standard
	Min.	Max.	Avg.	Median	
Biological					
Total Coliform	30	3700	405	280	No Standard
Fecal Coliform	0	1650	22	5	H mean #20
Physical and Chemical Characteristics					
Turbidity (NTU)	0.1	2.5	0.55	0.4	See narrative text.
Color (units)	7	120	39	33	HH 15
Dissolved Oxygen	39%	114%	89%	92%	H min. 75%
Temperature	0EC	23EC	9EC	9EC	H max. #20EC
pH (units)	5.1	7.5	6.31	6.2	H 6.5-8.3
Alkalinity (mg/L as CaCO3)	1.3	31.1	6.5	5.2	See narrative text.
Hardness (mg/L as CaCO3)	4.9	33.8	12.3	11.5	See narrative text.
Specific Conductance (micromhos per cm)	5	125	63	63	See narrative text.
Inorganic Compounds					
Iron	0.02 PPM	0.98 PPM	0.29 PPM	0.25 PPM	HH 0.3 PPM
Chlorides	2.4 PPM	23.5 PPM	10.4 PPM	10.1 PPM	HH 250 PPM

Notes:
H *MA Inland Class A Water Body Standards* - Minimum criteria required for surface waters to sustain and protect them from the degradation of their designated use(s).
HH *MA Secondary Drinking Water Standards* - Used in the absence of available raw water quality standards. These standards and meant only to serve as a guide, the parameters are not known to cause a health risk but may affect the taste, odor and color of water.
1.) Coliform concentration reported as number of colonies per 100 mL.
2.) PPM - Parts per million, equivalent to one drop in 10 gallons. 1 PPM = 0.9997 mg/L.

Table 10b – 2000 Tributary Water Quality Data: Ware River Watershed					
Parameter	Observed Range of Values				Massachusetts Water Quality Standard
	Min.	Max.	Avg.	Median	
Biological					
Total Coliform	7	5300	402	266	No Standard
Fecal Coliform	0	360	22	5	H mean #20
Physical and Chemical Characteristics					
Turbidity (NTU)	0.3	4.3	0.97	0.7	See narrative text.
Color (units)	7	240	60	45	HH 15
Dissolved Oxygen	8%	116%	82.7%	88%	H min. 75%
Temperature	0EC	26EC	11EC	10EC	H max. #20EC
pH (units)	5.5	7.1	6.28	6.3	H 6.5-8.3
Alkalinity (mg/L as CaCO3)	1.9	24.1	6.4	5.7	See narrative text.
Hardness (mg/L as CaCO3)	6.3	28.9	13.5	11.5	See narrative text.
Specific Conductance (micromhos per cm)	33	270	87.6	65	See narrative text.
Inorganic Compounds					
Iron	0.03 PPM	3.2 PPM	0.66 PPM	0.52 PPM	HH 0.3 PPM
Chlorides	4 PPM	67.9 PPM	18.6 PPM	13.5 PPM	HH 250 PPM

otes:

H *MA Inland Class A Water Body Standards* - Minimum criteria required for surface waters to sustain and protect them from the degradation of their designated use(s).

HH *MA Secondary Drinking Water Standards* - Used in the absence of available raw water quality standards. These standards are meant only to serve as a guide, the parameters are not known to cause a health risk but may affect the taste, odor and color of water.

1.) Coliform concentration reported as number of colonies per 100 mL.

2.) PPM - Parts per million, equivalent to one drop in 10 gallons. 1 PPM = 0.9997 mg/L.

Specific Conductance

Conductance is principally used as an indicator of the amount of dissolved minerals within the water. Specific electrical conductance is the measure of the ability of water to conduct an electrical current, which is dependent on the concentration and availability of mineral ions. Elevated levels may be indicative of contamination from road salting, septic system effluent, stormwater discharges or agricultural runoff. Soil type will also have an impact on ion leaching which may help to explain variability among “pristine” sources.

Inorganic Compounds

Iron (Fe)

Iron is a natural element found in rocks, soil and used widely in steel products and in water supply piping. Iron is generally found in natural water bodies at concentrations below 0.5 mg/L. Concentrations greater than 0.1 mg/L can precipitate after exposure to the air, causing staining and objectionable tastes.

Chlorides

The secondary drinking water standard for chloride is 250 mg/L to avoid brackish tastes. Salt used for highway de-icing is typically the principal source of surface and groundwater contamination. Other sources include sedimentary rocks and waste discharges from hard water softener units.

Reservoir Monitoring

Provided below is a brief discussion of selected parameters that are monitored in the Quabbin Reservoir between the months of March through December. Appendix B contains plots of reservoir profile data for selected water quality parameters. Information in this section was referenced from Principles of Water Quality (1984).

Temperature

The thermal stratification that occurs in the reservoir has a profound impact on many of the parameters monitored throughout the reservoir profile. The temporal zones that develop within the reservoir during the warmer months of spring and summer, known as the epilimnion, metalimnion and hypolimnion (listed in order from top to bottom), have distinct thermal, water flow and water quality characteristics. Waters of the epilimnion are warm and well mixed by wind driven currents, and, may become susceptible to algal growth due to the availability of sunlight and entrapped nutrients introduced to the partitioned layer of surface water. Within the metalimnion the thermal and water quality transition occurs between the warmer surface waters and colder, deep waters. The much deeper hypolimnic waters remain stagnant, have no circulation, and are susceptible to decaying matter and sediments that settle out from the upper layers or warmer water. Each year the reservoir is completely mixed due the settling of cooler surface waters at the time of springtime ice-out and during the cooling or surface waters in the fall.

Dissolved Oxygen

Wind driven turbulence, reservoir currents, atmospheric diffusion, and the respiration and uptake by phytoplankton and biological activity principally drive reservoir oxygen levels. The dissolved oxygen profile of the reservoir will typically mimic that of temperature.

pH and Alkalinity

Three processes principally reflected in reservoir pH and alkalinity dynamics are direct acidic inputs (i.e. rainfall), biological respiration and algal photosynthesis. The input of acid in the form of direct precipitation will consume alkalinity available in the water and reduce pH levels. Through respiration, the intake of oxygen and release of carbon dioxide by organisms, alkalinity levels will be augmented due to the input of carbon to the water. Photosynthesis may consume free carbon dioxide and bicarbonate resulting in a decrease in alkalinity and an increase in pH.

Secchi Disk

A standard 20 cm diameter black and white Secchi disk is used to measure transparency. Transparency can be greatly influenced by the level of phytoplankton activity but is also sensitive to weather and reservoir conditions at the time of sampling. Between 1990 and 1999 transparencies for the three reservoir stations ranged from a minimum of 2.9 meters (Den Hill) to a maximum of 12.7 meters (Shaft 12).

4.0 SPECIAL INVESTIGATIONS

Provided below is a brief overview of specialized studies and investigations that were undertaken by the DWM in CY 2000 to provide further insight into reservoir and tributary dynamics. Sampling results from field investigations are included in Appendix E**,** under Special Investigations.

Pathogen Monitoring

In coordination with the MWRA, the MDC continued its monitoring program for pathogens at the point of entry to the Chicopee Valley Aqueduct. A total of twenty four samples were collected biweekly from a tap inside the Winsor Power Station (representative of water entering the intake at approximately 70 feet below the reservoir surface). The pathogenic organisms of specific concern are Cryptosporidium spp. oocysts and Giardia spp. cysts because of their relatively high resistance to disinfectants, prolonged life-cycles and their low doses of infectivity. Sample collection and analysis follows protocols established for the immunoflourescence assay method (IFA Method) under the EPA's 1996 Information Collection Rule. The Erie County Water Authority of New York performs the analysis. MDC staff performs the necessary filtering process during collection and ships the ice-preserved samples within 48 hours of collection. Equipment utilized during collection includes a flowmeter, polypropylene-wound filter cartridge (1 um), and clear laboratory tubing. A target sample volume of 100 gallons was attained during each sampling event. Results of this sampling program are being reported separately by the MWRA following further analysis and review.

Stream Surveys

DWM staff continues to monitor site-specific water quality impacts related to development pressures, wildlife populations, and construction activities occurring throughout the watershed. Table 11 summarizes DWM staff investigations, activities and findings. Further information on field sampling and stream survey investigations can be found in Appendix D of this report.

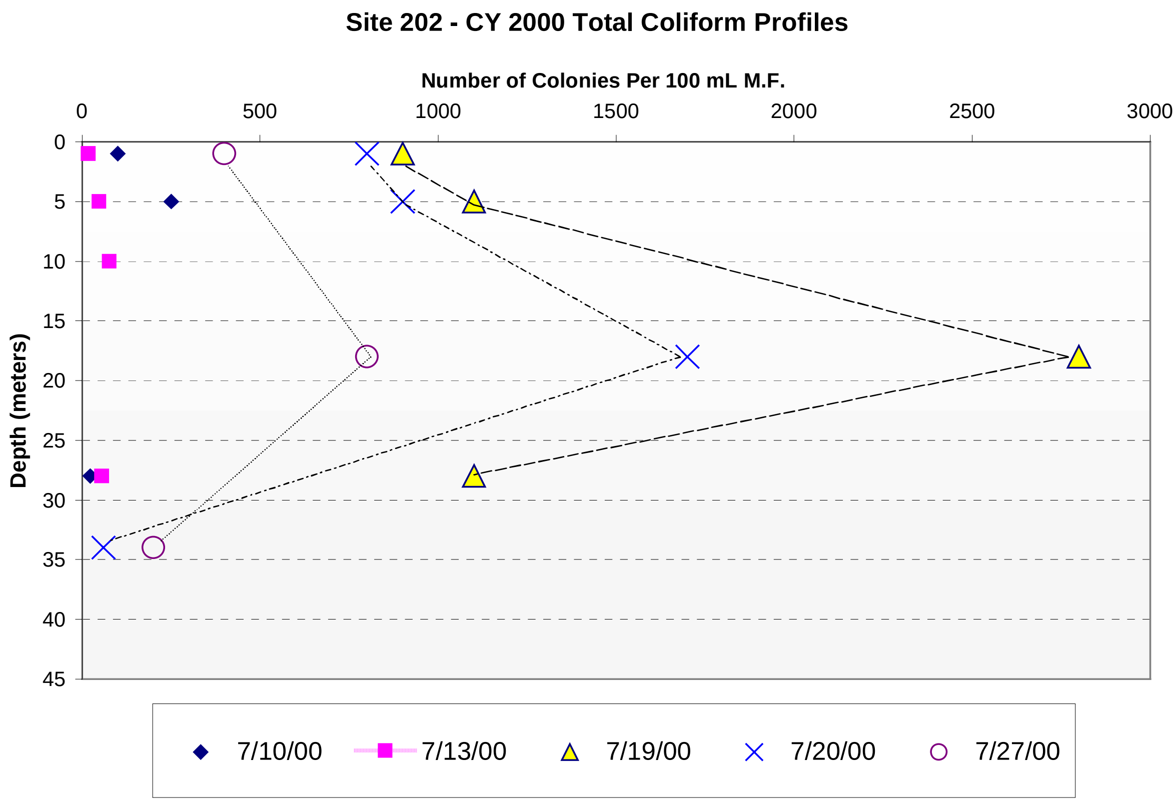
Reservoir Phytoplankton and Nutrient Dynamics

MDC/DWM staff continues to examine the taxonomic composition, density, and seasonal dynamics of the plankton community of Quabbin Reservoir. This work is being performed together (samples collected simultaneously at identical locations) with special nutrient sampling that is examining reservoir levels of total phosphorous, total kjeldahl nitrogen, nitrate, ammonia, and silica. The combined sampling program consists of quarterly monitoring at three reservoir stations; Winsor Dam, Shaft 12 and Den Hill. Analytical results from this ongoing study are included the Appendix C of this report. For further information a companion MDC report is available for review entitled "Nutrient and Plankton Dynamics in Quabbin Reservoir: Results of the MDC/DWM's 1998-99 Sampling Program".

Table 11. 2000 Special Investigations and Sampling Events			
Stream Basin/ Location	**Date(s)**	**Samples Collected?**	**Results**
Demond Pond	February 29	Yes (Bacteria)	Bacteria results inconclusive. Gull feces found on ice near ice fishing holes.
Boat Cove Brook	May 1	No	Follow-up stream survey in response to elevated bacteria levels.
Winsor Dam	May 25	No	Shoreline survey of geese activity on Hangar lawns that may have contributed to “spike” in bacteria recorded from the tap located inside the Winsor Power Station.
Quabbin Reservoir	July 10 July 13 July 19 July 20 July 27	Yes (Bacteria)	Reservoir profile samples collected to characterize unexplained spikes in-reservoir total coliform dynamics.
Queen Lake	September 27 October 17	Yes (Bacteria)	According to local residents, geese a problem in particular inside fire pond immediately upstream of SS.
Petersham Brook (West Street Hydrant)	November 15 December 7	Yes (Bacteria)	Response to odor complaints reported during dry hydrant construction. Potential sewage source ruled out as a cause of the odor.
Boat Cove Brook	December 12	No	Bacterial source survey; no beaver re-established on brook. Deer scat suspected source of elevated bacteria.

Reservoir Total Coliform Dynamics

The MDC initiated a very brief response to elevated levels of total coliform bacteria observed in results from the 201 Winsor Power Station Sample Site during the July through October period. On four separate occasions in July, in-reservoir samples were collected to profile the occurrence of bacteria at depth and to evaluate spatial differences in bloom occurrences. In each instance, variability was observed at depth and day to day fluctuations in numbers was common. Common to all sampling results at depth, fecal coliform densities were consistently at or near zero. Total coliform results from Site 202 are plotted below. A program of routine weekly reservoir profiling for coliform bacteria is being planned for CY 2001 beginning in June.



Natural Organic Matter

In August 2000, an extensive field sampling program that was begun in February 1998 ended. The extensive baseline of data obtained from this three-year study of natural organic matter dynamics in Quabbin Reservoir provided some relevant data on the topic of precursors of disinfection byproducts. Specifically, Garvey et al (2001) concluded the following:

- Overall, most parameters studied (TOC, DOC, UV) were a poor predictor of THMFP in reservoir water partially attributable to the low variability in reservoir data (r^2 values ranged between 0.12 and 0.49).
- A weak but positive relationship was observed between THMFP yields of the reservoir and the abundance of blue green algae (r^2=0.54).
- Based on a determination of mass balances, net algal productivity was determined to be the single largest input of natural organic matter, estimated at 1 to 3 times the total allochthonous inputs.

Table 12. Total Coliform Colonies Per 100 mL at Reservoir Stations Sampled During CY 2000 Special Investigations.

Winsor Basin	202						3A					West Arm						
Depth (m)	1	5	10	18	28	34	1	5	18	28	35	1	5	18	28	35		
July 10	100	250	NS	NS	22	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
July 13	18	47	76	NS	55	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
July 19	900	1100	NS	2800	1100	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS		
July 20	800	900	NS	NS	TNTC	60	1900	1700	5000	2500	1700	LA	LA	7500	2100	1600		
July 27	400	TNTC	NS	800	NS	200	900	NS	4000	NS	NS	NS	NS	NS	NS	NS		
Central Basin	Shaft 12 (206)					206 North					206 South							
Depth (m)	1	5	24	28	35	1	5	7	10	28	1	5	9	13	28			
July 10	2	2		1	NS	1	3	NS	NS	1	1	3	NS	NS	2			
July 20	100	540	400	NS	120	20	100	100	600	NS	100	540	500	1400	NS			
July 27	500	880	500	NS	500	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS			
Misc.	Mid Shaft 12			Den Hill			206 East				3A East					3A West		
Depth (m)	1	5	28	1	5	17	1	5	12	16	1	5	18	28	35	1	18	25
July 10	7	2	1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
July 20	NS	NS	NS	UC	UC	400	100	260	180	120	760	2400	7300	1400	1700	3100	UC	1700

Notes:
NS – No Sample
LA – Lab Accident
TNTC – Too numerous to count

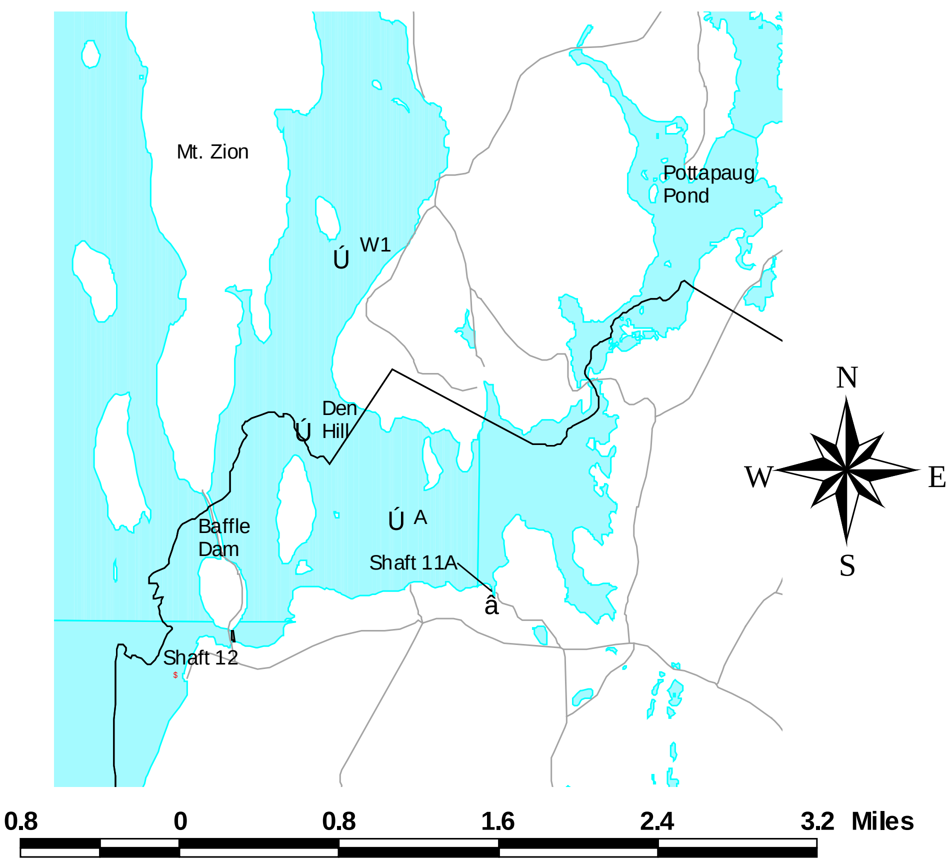
GPS Coordinates:

Shaft 12	N 42E22.175’ W72E17.100’	Mid Shaft 12	N 42E22.195’ W72E16.828’
206 North	N 42E22.631’ W72E17.499’	206 South	N 42E22.000’ W72E17.588’

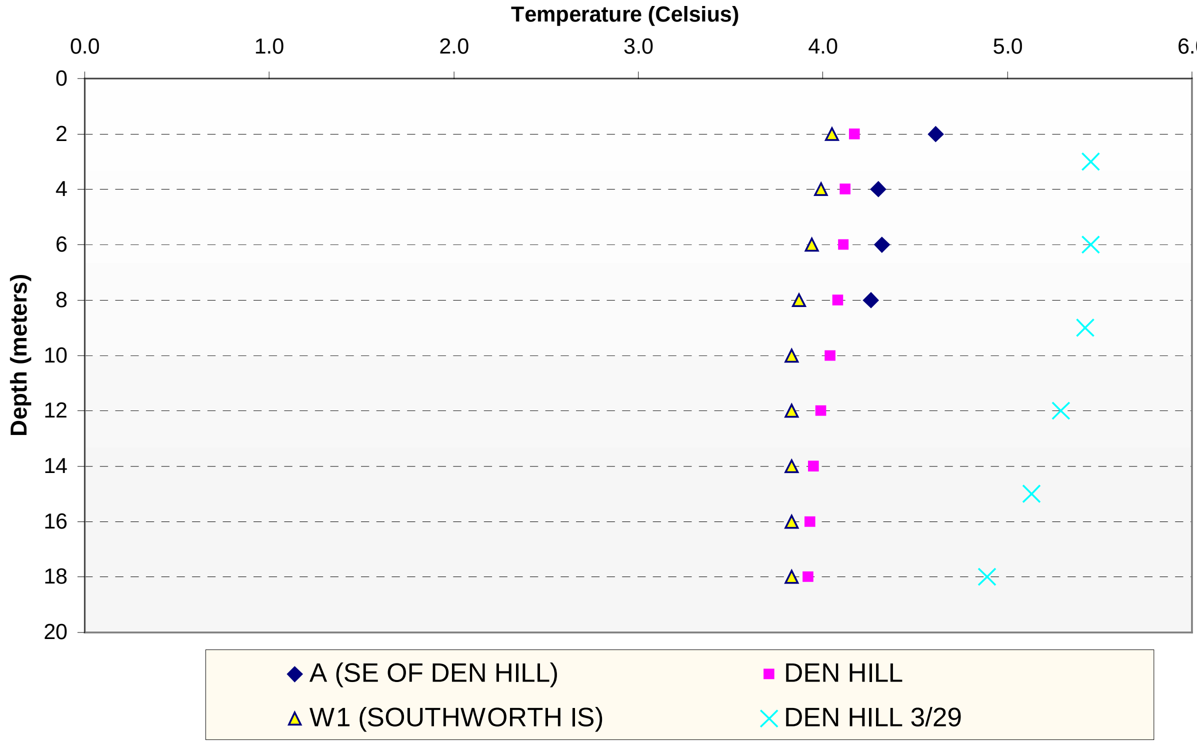
Ware River Diversion

The MDC initiated a very brief sampling program to study the mixing dynamics of Ware River water as it enters Quabbin Reservoir's East Arm via the outlet at Shaft 11A. A total of 603.8 million gallons of Ware River water was diverted over a span of six days beginning on March 21 and ending March 28. In-reservoir sampling at three stations was performed on March 23, March 29, April 6 and April 13. Results from the March 23 sampling event are plotted on the following page. Sampling was discontinued due to a halt in the diversions as a result of a small hydraulic oil leak from equipment housed inside of the Shaft 8 intake works facility.

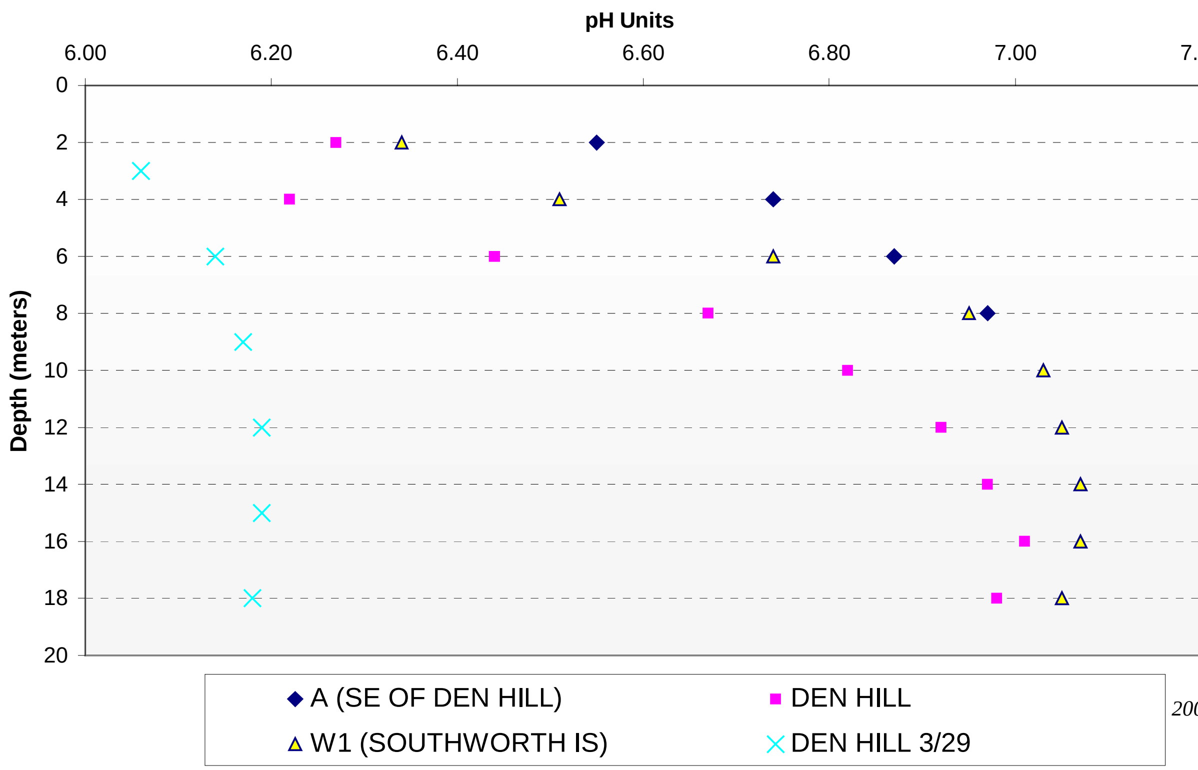
Ware River Diversion Study CY 2000
Sample Site Locations



WARE RIVER DIVERSION - MARCH 23, 2000 Temperature Profiles



WARE RIVER DIVERSION - MARCH 23, 2000 pH Profiles



2001

Section 4.0A

Incident Report Forms
Stream Surveys

FY2000 Bacteria Event Follow Up Survey No. 1 M. Hopkinson

On Tuesday, February 29, 2000, a special sampling program was conducted at Demond Pond, Pleasantdale Road, Rutland. The special sampling was in response to an unexplained increase in bacteria levels measured in routine biweekly sampling at the pond outlet. Sample results over 15 fecal colonies per I 00 ml are reported to the EQS. From June to October, no such events were recorded at Demond Pond. Beginning on October 25, 1999, bacteria levels increased dramatically, ranging between 16 and 87. (see graph).

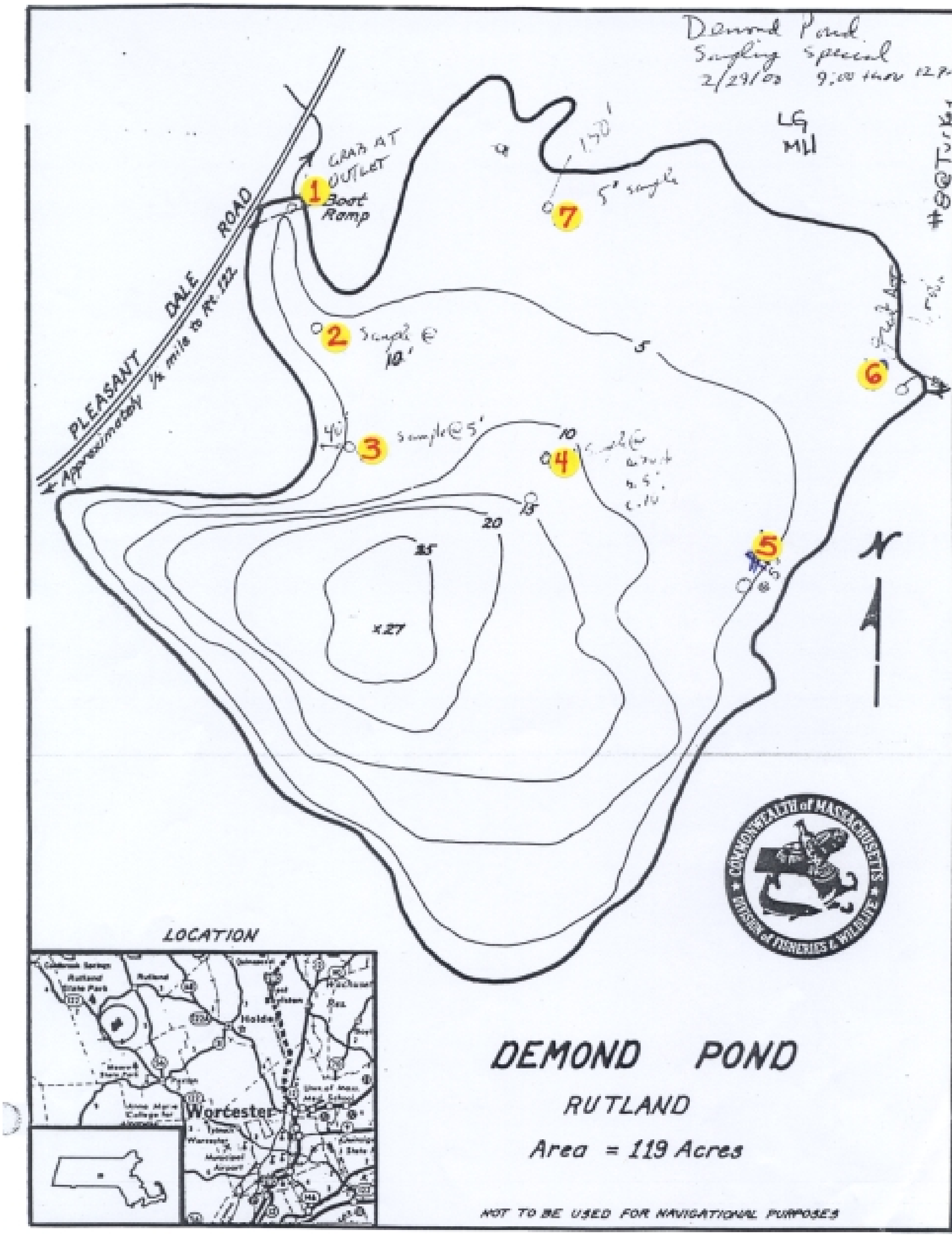
As a result, a special sampling program was conducted. Lisa Gustavsen and Matt Hopkinson of the MDC collected IO samples from eight sample sites on February 29. Three site-specific locations were selected, along with a transect across a narrow section of the pond. One additional site was chosen within the channel leading to the outlet. The attached map shows the sites.

1. Grab sample from outlet
2. IO' depth at outlet channel
3,4 and 5. Composed the cross-section. At site 4, samples were collected from the surface,-five-feet andlen-feet,depth. The maximum depth along the cross-section was estimated to **be** twelve feet.
6. Grab sample at stream inlet
7. 5' depth off developed shoreline
8. Grab sample at Turkey Hill Road, on same inlet stream as #6.

During the sampling program, a significant amount of bird feces, presumably gull covered the ice. There were also a lot of ice-fishing holes. There were no birds or fishermen present on the day of sampling. The weather was below freezing and very windy.

Lab results revealed no obvious source of the bacteria. The grab sample at the outlet was at I colony/I 00mi. The highest measured level was 7, at the inlet. It was judged that any event associated with the elevated bacteria was not observed on this date. A link between ice fishing and fish scavenging by gulls would not account for the October commencement of the elevated levels. It is possible that weekend activities at the boat ramp were contributing to the regular Monday samples.

Matthew H. Hopkinson, **PE**



Demond Pond
Sampling special
2/29/00 9:00 thru 12
LG
MH
GRAB AT OUTLET
Boat Ramp
PLEASANT DALE ROAD
Approximately ½ mile to Rt. 122
1
2
3
4
5
6
7
Sample @ 10'
sample @ 5'
5' sample
40'
5
10
15
20
25
x27
LOCATION
Worcester
DEMOND POND
RUTLAND
Area = 119 Acres
NOT TO BE USED FOR NAVIGATIONAL PURPOSES
COMMONWEALTH of MASSACHUSETTS
DIVISION of FISHERIES & WILDLIFE

EQ FILE REPORT

Inspector: P. Reyes
File # WR-004
Date: 10/17/00

[x] Field Investigation

[ ] Meeting
[ ] Phone Conversation

District: Burnshirt, Canesto, & Natty
Subdistrict: Queen Lake
Time: 9:00 – 10:00
Weather: Overcast, temperature in the upper 50's, rain previous night

Activity

Wastewater	[ ] Construction	Haz. Waste
[Agricultural	[ ] Sedimentation/Erosion	Recreation
Wildlife	[ ] Trash/Dumping	[x] Other - unknown

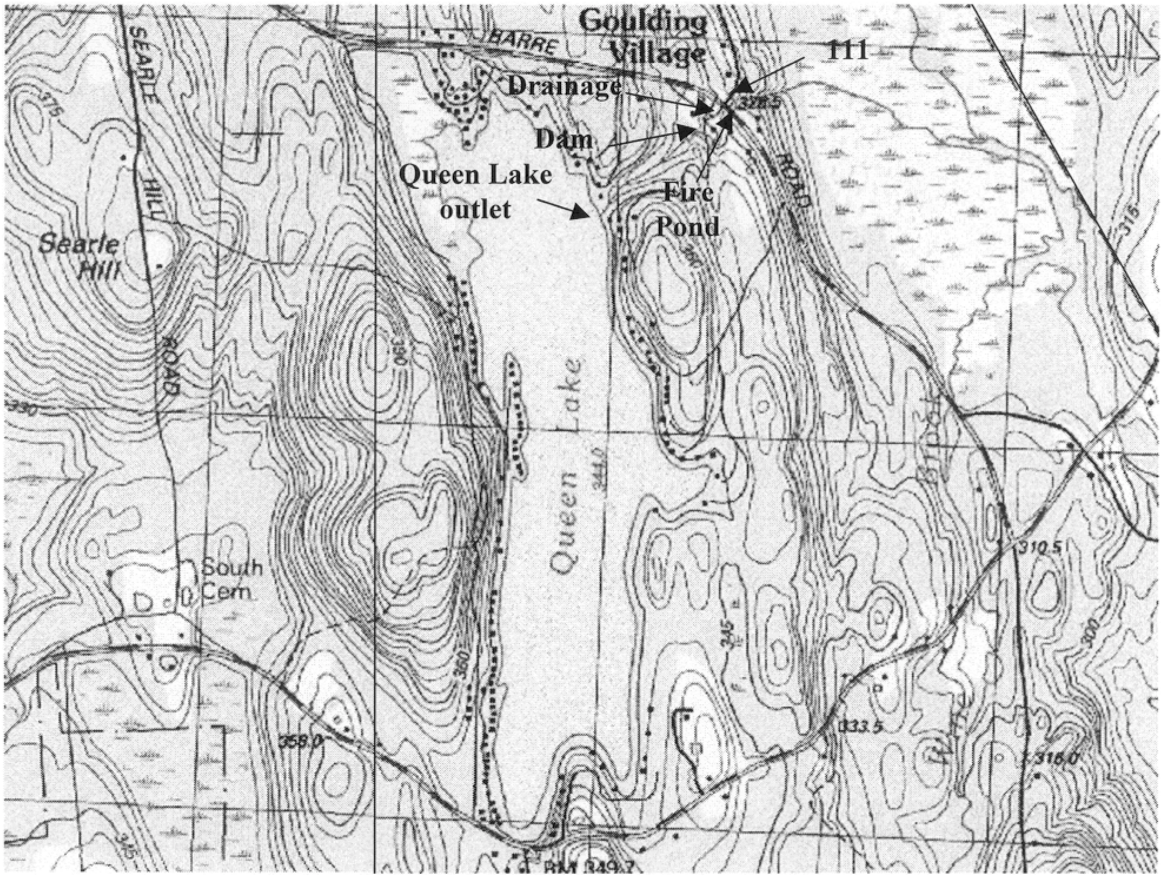
Results from 9/25/00 biweekly sampling at the Queen Lake sampling site (MDC 11) showed unusually high fecal coliform concentrations (see attached map). Sampling of Queen Lake itself showed that the contamination did not originate there. Therefore, a search for possible causes was undertaken upstream from the sampling site on 10/05/00. No obvious causes were found, but a number of possibilities were considered. These included contamination of the fire pond by wildlife, release of bacteria from sediments by partial draining of the pond by the fire department, or contamination from a faulty septic system. Since no obvious causes were found, MDC staff conducted targeted sampling on 10/17/00 in an attempt to isolate the problem. Five samples were collected at this time.

Lab analysis of the samples showed that fecal coliform counts had returned to normal levels. No definite cause was found for the problem, but a possible source was identified after a conversation with a local resident, a Mr. Wilson. At the time of the elevated counts, migrating geese made frequent stops at a pond behind house # 260, and probably contaminated the water. Once the geese stopped flying in, the problem stopped. The following table shows sampling, date, site and results.

Sampling Date	Sampling Site	Fecal Coliforms/100 ml
9/25/00	111	137
11/17/00	111	20
	Drainage downstream from fire pond and southwest of Barre Road	6
	Fire Pond	10
	Downstream of dam (behind # 260)	18
	Queen Lake shore at outlet	0

Signature of inspector

(eqrpt.vr2) (Signed under the paines and penalties of perjury)



Queen Lake, Phillipston: Coliform Bacteria Colonies Per 100 mL MF

---------Direction of flow ---------->

	Date	Queen Lake Shore near outlet	Dam	Fire Pond	Ditch (Drainage Pipe)	111 (Routine SS)
Fecal Coli	27-Sep-00	0	-----	-----	-----	90
Total Coli	27-Sep-00	40	-----	-----	-----	600
Fecal Coli	17-Oct-00	0	18	0	6	12
Total Coli	17-Oct-00	TNTC	440	420	TNTC	390

EQ FILE REPORT

File # QHYD_012.00
Date: 12/7/00

[X] Field Investigation
[ ] Meeting
[ ] Phone Conversation

Site: West Street Dry Hydrant
Time: 1:00 PM
Weather: MC, 20's (prev. 48 hrs dry)

<u>Activity</u>

[ ] Wastewater	[ ] Construction	[ ] Haz. Waste
[ ] Agricultural	[ ] Sedimentation/Erosion	[ ] Recreation
[ ] Wildlife	[ ] Trash/Dumping	[X] Other-Unknown

On November 15 and Decmber 7, 2000 follow-up bacterial sampling was conducted in response to odor/discoloration complaints received from a local resident, a Mr. James Ermini. The complaints stem from dry hydrant construction work overseen by town personnel on October 26, 2000. During construction of the 50 ft wide, 20 ft long and 8 ft deep hydrant pool a significant amount of organic decaying material was unearthed from beneath the pool level of the pond. As a result, water clarity in the newly created pool was highly turbid with a milky brown color.

In follow-up sampling by the MDC water levels inside the pool had reached capacity and the pool was releasing water downstream. Water clarity conditions had improved during each round of sampling but water clarity of the dark colored water remained poor despite visible reductions evident in turbidity levels. Sample sites were selected at the entrance to the hydrant pool, at depth inside the pool, at the hydrant pool outlet, and at a reference station approximately ½ mile downstream (see map).

Laboratory results indicate differences in water quality between wet weather flows and dry flow conditions. An upstream network of street piping and catch basins, coupled with the close proximity of a horse pen, provides an easy means of bacterial transport directly to the stream during wet weather conditions. A major objective of the sampling program was to rule out the possibility of a direct connection of a sewer pipe to the tributary. Based on the relatively low levels of fecal coliform bacteria (densities in raw sewage could be expected to be 13,000,000 colonies per gram of feces) and the apparent variation based on stream flow conditions, a direct discharge of piped sewage appears unlikely.

Follow Up?

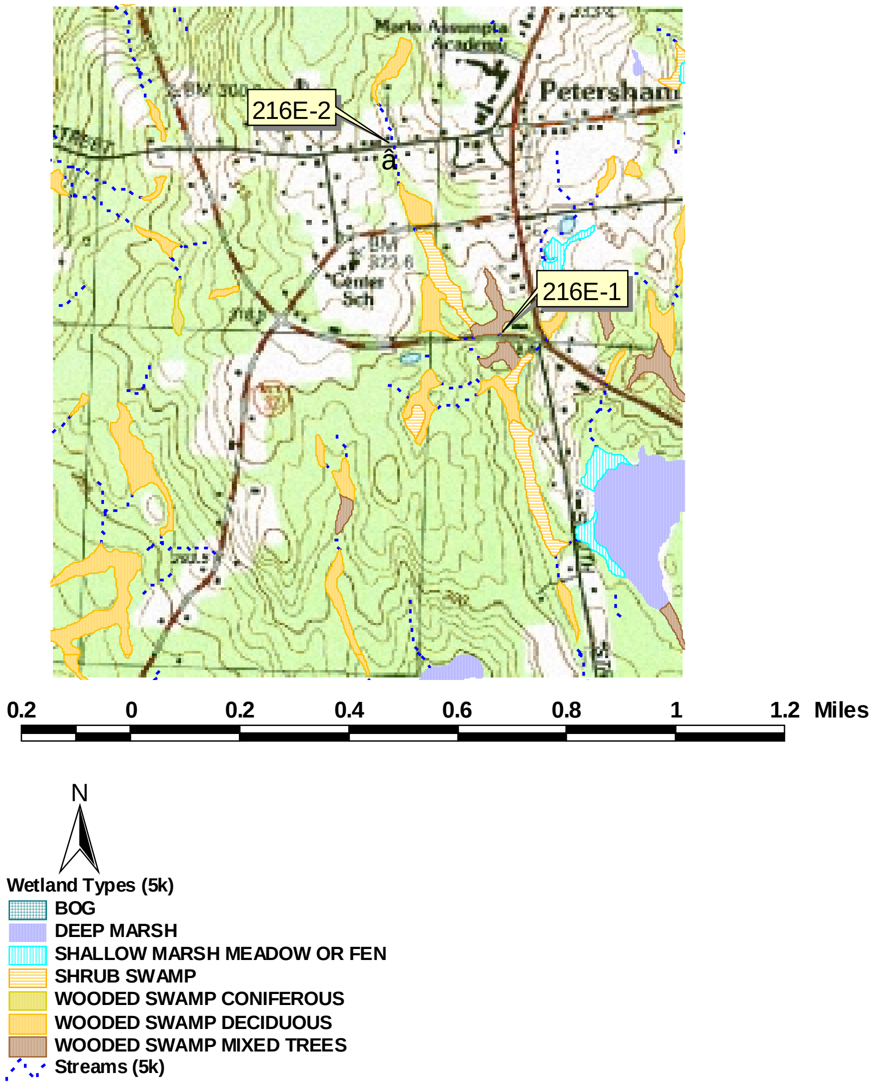
Periodic monitoring of various flow conditions recommended.

Signature of inspector

(eqrpt.vr2)

(Signed under the paines and penalties of perjury)

West Street Dry Hydrant / Petersham Center



West Street Dry Hydrant, Peterhsam: Fecal Coliform Colonies Per 100 mL MF

Flow Type	***Date***	***Dilution***	***216E-1*** *Rt122 crossing*	***216E-2*** *Spring St. Culvert*	***216E-2A*** *Dry Hydrant Outlet*	***216E-2B*** *Dry Hydrant Pool*
Wet	15-Nov-00		11	TNTC	TNTC	TNTC
Weather	15-Nov-00	X 10	-----	-----	690	720
Dry	7-Dec-00		2	-----	3	-----
Weather	7-Dec-00	X 2	-----	4	-----	-----
	7-Dec-00	X 10	-----	20	0	-----
	7-Dec-00	X 20	-----	0	20	-----

APPENDICES

A - U.S. GEOLOGICAL SURVEY FLOW DATA - 2000 WATER YEAR

B - RESERVOIR PROFILES

C - QUABBIN RESERVOIR NUTRIENT CONCENTRATIONS

D - 2000 WATER QUALITY DATA TABLES

References:

American Public Health Association, 1998. Standard Methods for the Examination of Water and Wastewater - 20th Edition. Washington D.C..

Clark et al, 1977. Water Supply and Pollution Control. Harper and Row, New York.

Geldreich, E.E., 1968. “Fecal Coliform Concepts in Stream Pollution.” Proceedings Symposium on Fecal Coliform Bacteria in Water and Wastewater, Bureau of Sanitary Engineering, State Dept. of Public Health, Berkeley, California.

Jakubowski, J. et al, September 1996. AEnvironmental Methods for Cryptosporidium≅, Journal American Water Works Association.

Long, S.C., May 1997. Development of Methods to Differentiate Microorganisms in MDC Reservoir Watersheds. Dept. of Civil and Environmental Engineering, University of Massachusetts, Amherst.

MA Executive Office of Environmental Affairs, 1999. MA Geographical Information System.

Metropolitan District Commission, 2000. Meteorological Records. MDC unpublished reports.

Streeter, H.W., 1934. “Formulation of Bacterial Changes Occurring in Polluted Water.” *Sewage Works Journal*, Vol. 6, No. 2.

Tobiason J.E., Ahlfeld D.P., Edzwald J.K., Reckhow D.A., Long S.C., April 1999. Water Quality in MDC Reservoirs. Unpublished research proposal to the Metropolitan District Commission prepared by the Department of Civil and Environmental Engineering, University of Massachusetts at Amherst.

Tobiason J.E., Male J.W., Reckhow D.A., September 1996. Contaminant Transport Modeling and the Impact of Watershed Management Activities on Water Quality in Quabbin Reservoir. Environmental Engineering Program, University of Massachusetts at Amherst.

U.S. EPA, 1986. Water Quality Criteria for Water

Waite, T.D. 1984. Principles of Water Quality. Academic Press, Florida.

APPENDIX A

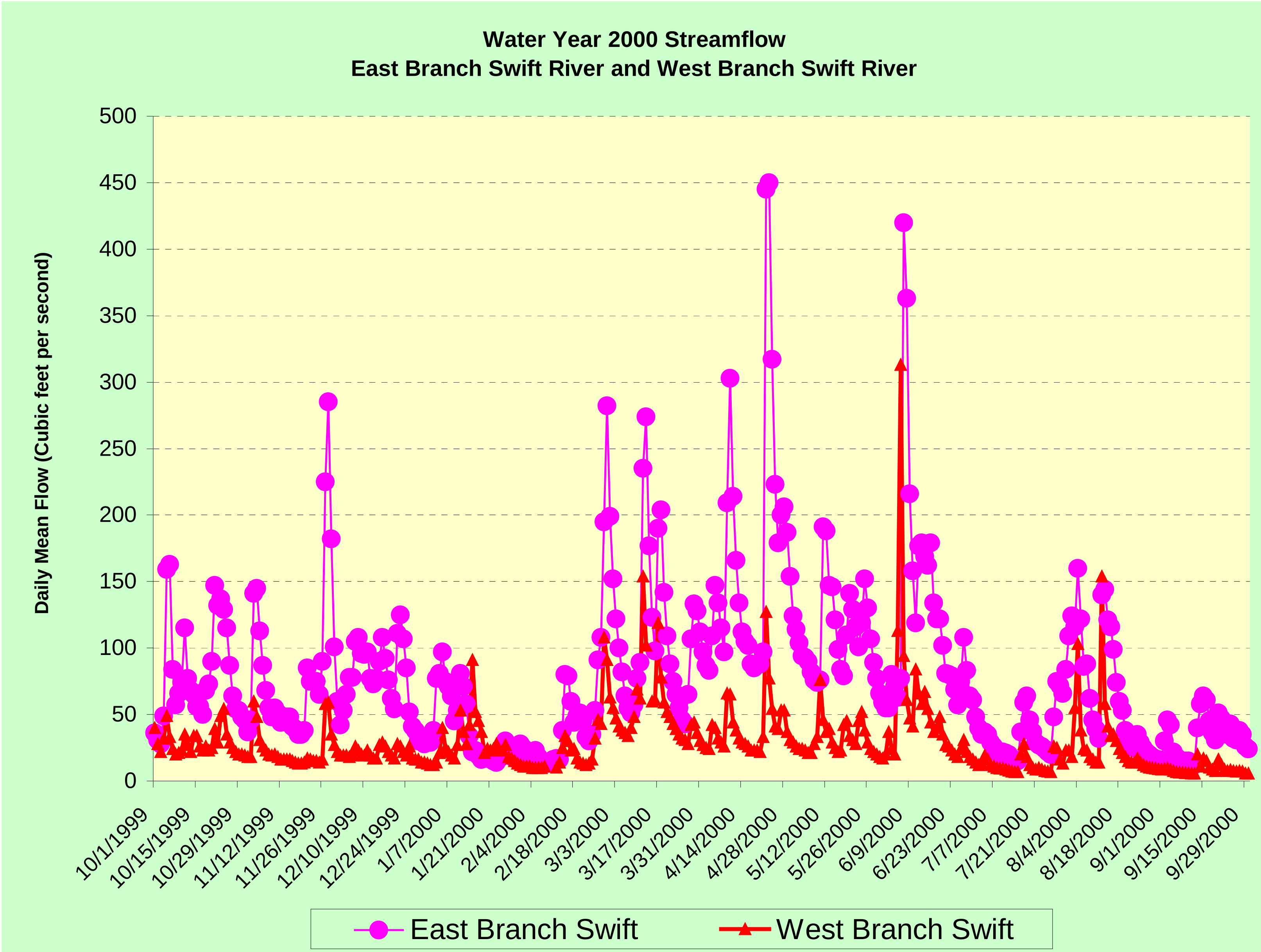
U.S. GEOLOGICAL SURVEY FLOW DATA - 2000 WATER YEAR:

EAST BRANCH SWIFT RIVER

WEST BRANCH SWIFT RIVER

WARE RIVER AT INTAKE

SWIFT RIVER BELOW DAM



Water Year 2000 Streamflow
East Branch Swift River and West Branch Swift River
Daily Mean Flow (Cubic feet per second)
500
450
400
350
300
250
200
150
100
50
0
10/1/1999
10/15/1999
10/29/1999
11/12/1999
11/26/1999
12/10/1999
12/24/1999
1/7/2000
1/21/2000
2/4/2000
2/18/2000
3/3/2000
3/17/2000
3/31/2000
4/14/2000
4/28/2000
5/12/2000
5/26/2000
6/9/2000
6/23/2000
7/7/2000
7/21/2000
8/4/2000
8/18/2000
9/1/2000
9/15/2000
9/29/2000
East Branch Swift
West Branch Swift

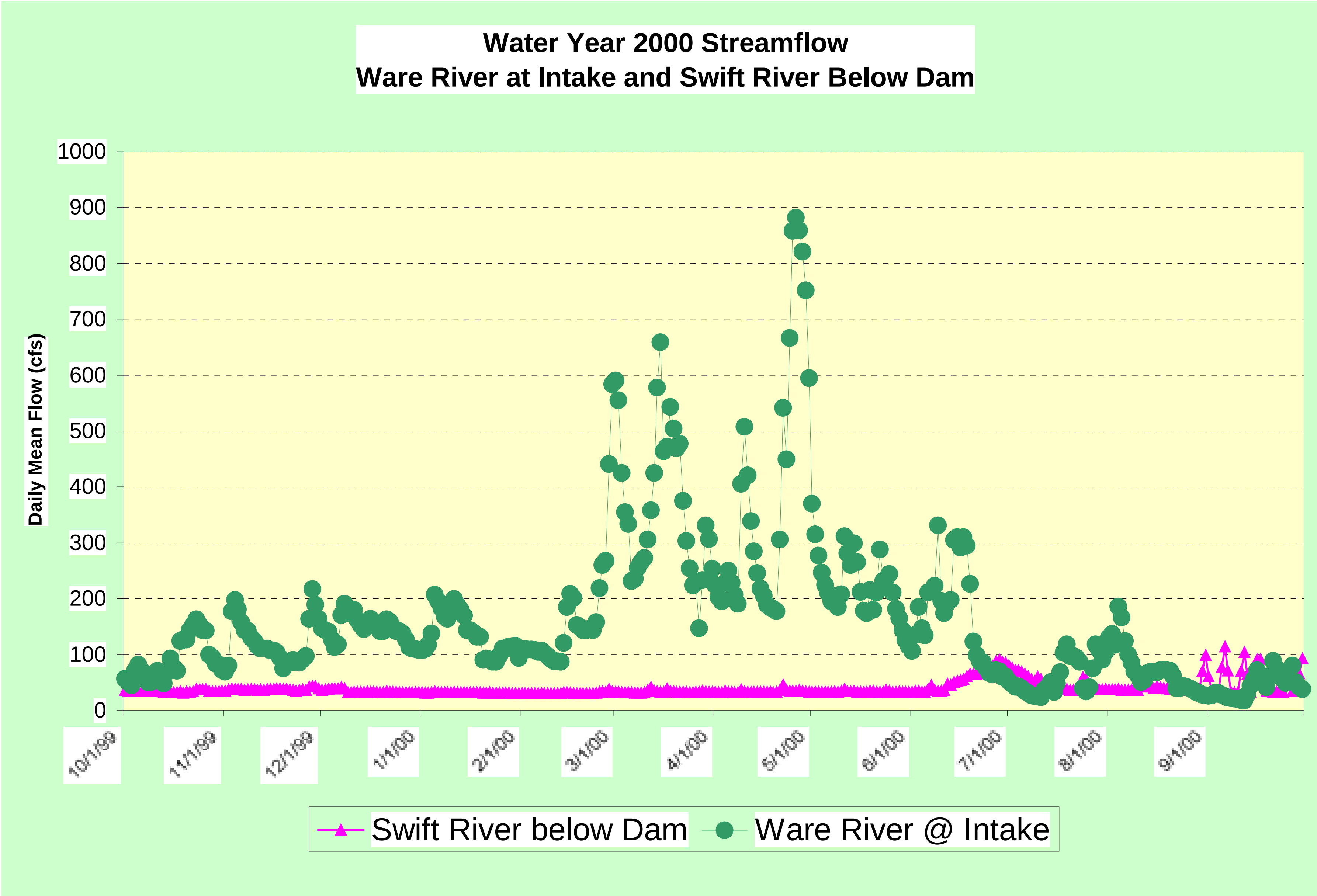
01174500 EAST BRANCH SWIFT RIVER NEAR HARDWICK
WATER YEAR 2000 (OCT 1999 - SEP 2000)
PROVISIONAL DATA

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	36	37	60	29	25	199	97	124	55	48	109	15
2	31	46	42	38	21	152	87	114	55	40	124	30
3	28	141	53	77	18	122	83	104	80	35	116	46
4	49	145	65	81	22	100	109	94	71	37	160	42
5	159	113	78	97	23	82	147	93	63	35	122	22
6	163	87	78	75	18	64	134	90	77	29	86	18
7	84	68	105	71	15	55	115	82	420	26	88	16
8	57	55	108	64	13	51	97	76	363	22	62	15
9	66	48	96	45	13	57	209	74	216	20	46	15
10	74	55	95	53	14	77	303	76	158	22	39	15
11	115	51	97	81	16	89	214	191	119	21	32	13
12	77	44	77	71	17	235	166	188	177	20	140	12
13	68	45	73	58	16	274	134	147	179	17	144	40
14	65	48	77	34	38	177	112	146	169	15	121	58
15	56	48	90	22	80	123	105	121	162	15	116	64
16	56	41	108	23	79	98	102	99	179	37	99	61
17	50	39	92	19	60	190	88	84	134	59	74	45
18	68	35	76	16	44	204	85	79	122	64	60	36
19	73	35	62	17	49	142	87	110	122	46	53	31
20	90	38	54	17	51	109	88	141	102	37	38	51
21	147	85	111	18	45	88	97	129	81	29	32	47
22	132	75	125	15	33	75	445	116	80	27	28	37
23	137	75	107	14	30	65	450	101	79	26	25	35
24	129	75	85	17	35	55	317	119	69	24	35	43
25	115	65	52	23	53	46	223	152	57	22	29	32
26	87	90	41	30	91	43	179	130	75	20	25	31
27	64	225	38	24	108	65	200	107	108	48	22	38
28	54	285	30	19	195	107	206	89	83	75	20	35
29	53	182	30	17	282	133	187	77	64	72	18	26
30	48	101	28	17		128	154	66	61	66		24
31	46		31	28		112		59		84	16	
DAILY MEAN FLOWS (reported in cfs)												
TOTAL	2477	2477	2264	1210	1504	3517	5020	3378	3780	1138	2079	993
MEAN	79.90	82.57	73.03	39.03	51.86	113.45	167.33	108.97	126.00	36.71	69.30	33.10
MAX	**163**	**285**	**125**	**97**	**282**	**274**	**450**	**191**	**420**	**84**	**160**	**64**
MIN	28	35	28	14	13	43	83	59	55	15	16	12
STD DEV	38.22	59.61	27.99	25.59	58.69	59.20	98.66	32.91	85.62	19.21	45.07	14.87
HISTORICAL RECORDS: 1937-1999 (MEAN DISCHARGES)												
MEAN	38.6	63.5	76.7	82.5	82	136	160	91.8	58.4	29.1	22.6	26.4
MAX	155	177	264	240	207	266	420	189	175	179	127	390
MIN	2.55	6.93	19.9	5.3	18.5	48.2	34.8	30.5	6.87	3.23	0	0
REC. MAX?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
REC. MIN?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

HIGHEST DAILY MEAN?	450 cfs	23-Apr
	4690 cfs	Sep 21 1938
LOWEST DAILY MEAN?	12 cfs	12-Sep
	0 cfs	Aug 15 1939

01174565 WEST BRANCH SWIFT RIVER NEAR SHUTESBURY
WATER YEAR 2000 (OCT 1999 - SEP 2000)
PROVISIONAL DATA

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	40	18	22	12	11	63	27	29	20	14	23	8.6
2	28	18	19	12	11	55	25	26	37	12	18	9
3	22	60	19	14	11	47	24	24	24	13	55	9.3
4	32	48	19	21	9.9	41	42	24	20	19	103	8.8
5	49	31	18	40	9.7	38	40	23	113	16	38	7.5
6	33	26	19	25	9.7	36	32	21	313	12	24	6.8
7	24	23	26	22	9.7	34	29	21	94	11	23	6.5
8	20	20	23	19	11	40	26	28	61	9.6	18	6.3
9	21	19	20	17		48	66	33	47	9.4	16	6.2
10	23	20	19	27		69	65	76	41	9.5	14	6
11	35	18	23	53		62	44	46	84	8.7	14	5.8
12	27	16	19	37	10	154	38	37	66	7.8	154	5.5
13	22	16	17	28	14	102	32	39	58	7.2	58	20
14	34	16	17	42	25		29	29	67	6.8	41	11
15	34	16	27	91	34	60	28	25	54	6.9	34	17
16	26	15	29	52	30	61	26	22	44	20	35	15
17	23	14	26	45	23	119	23	23	37	28	30	10
18	26	13	22	37	24	78	23	42	40	18	24	8.7
19	23	13	19	21	17	59	23	45	48	12	21	7.7
20	25	14	17	24	14	52	22	34	35	9.8	18	16
21	39	17	28	23	13	48	33	31	27	8.7	15	12
22	29	16	26	24	12	43	127	28	26	9.8	14	8.8
23	49	15	22	28	13	39	77	45	23	8.6	14	7.5
24	54	15	19	23	16	35	54	52	20	7.6	17	8.1
25	35	14	26	23	32	32	41	38	18	7	14	7.4
26	29	16	17	27	46	31	39	29	24	6.7	12	7.3
27	25	58	16	18	43	28	53	24	31	26	11	7.7
28	22	59	16	17	108	42	53	22	22	25	10	7.3
29	20	35	14	15	91	44	37	20	18	16	9.7	5.8
30	20	27	14	13		36	31	18	16	13	9.3	5.7
31	19		13	12		30		17		23	8.9	
DAILY MEAN FLOWS (reported in cfs)												
TOTAL	908	706	631	862	648	1626	1209	971	1528	402.1	895.9	269.3
MEAN	29.29	23.53	20.35	27.81	24.92	54.20	40.30	31.32	50.93	12.97	28.90	8.98
MAX	54	60	29	91	108	154	127	76	313	28	154	20
MIN	19	13	13	12	9.7	28	22	17	16	6.7	8.9	5.5
HISTORICAL RECORDS: 1984-1999 (MEAN DAILY DISCHARGES)												
MEAN	11.3	21.1	30	32.8	37.8	43	38.7	31.3	22.1	10.2	3.79	10.9
MAX	23.9	39.2	75.3	51	70.6	60.1	83	78.1	52.8	24.3	7.71	52.9
MIN	2.58	6.98	7.19	11.1	13.6	30.5	15.3	10.5	3.73	1.98	2.03	1.02
REC. MAX?	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	YES	NO
REC. MIN?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HIGHEST DAILY MEAN?			313 cfs			6-Jun						
			636 cfs			Sep 17 1999						
LOWEST DAILY MEAN?			5.5 cfs			12-Sep						
			0.35 cfs			Sep 7 1995						


Water Year 2000 Streamflow
Ware River at Intake and Swift River Below Dam
Daily Mean Flow (cfs)
1000
900
800
700
600
500
400
300
200
100
0
10/1/99
11/1/99
12/1/99
1/1/00
2/1/00
3/1/00
4/1/00
5/1/00
6/1/00
7/1/00
8/1/00
9/1/00
Swift River below Dam
Ware River @ Intake

01173000 WARE RIVER AT INTAKE WORKS NEAR BARRE
WATER YEAR 2000 (OCT 1999 - SEP 2000)
PROVISIONAL DATA

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	57	69	147	107	110	590	225	370	106	52	130	26
2	51	80	144	110	110	555	203	315	135	47	137	27
3	45	177	141	117	109	425	195	277	185	42	117	31
4	71	198	127	138	109	355	228	247	147	43	186	31
5	82	181	113	207	108	334	250	225	134	40	166	28
6	71	158	118	196	105	231	228	210	211	35	124	25
7	59	144	171	183	107	236	207	195		31	100	23
8	51	143	191	168	102	255	191	194	223	27	85	22
9	51	130	178	164	98	265	405	185	331	25	70	21
10	67	124	173	175	92	273	508	208	196	26	63	20
11	71	116	180	199	88	306	421	312	174	24	51	19
12	62	111	162	188	88	358	339	281	192	36	54	18
13	48	111	153	180	87	425	285	260	198	41	67	28
14	68	111	145	170	121	578	246	299	305	51	69	44
15	93	107	154	144	185	659	218	265	310	33	68	56
16	77	107	164	144	209	464	205	212	291	48	68	72
17	71	104	156	139	201	472	189	178	310	68	72	59
18	124	95	156	132	153	543	184	174	295	103	73	49
19	127	75	142	132	149	504	182	215	226	118	72	41
20	127	84	142	90	144	469	177	180	123	97	71	62
21	144	85	163	93	144	477	306	211	99	97	62	89
22	153	90	159	91	146	375	541	288	87	95	40	75
23	163	86	149	87	144	303	449	231	86	87	40	64
24	153	85	142	87	158	254	666	236	76	40	44	56
25	144	91	142	98	219	224	858	244	67	34	42	49
26	143	97	138	111	260	229	882	211	64	41	40	52
27	100	164	127	110	268	147	859	182	72	75	37	80
28	95	217	113	114	441	233	821	165	70	118	33	51
29	84	189	111	115	584	331	752	144	60	108	31	42
30	82	164	110	116		307	595	126	61	90	28	38
31	73		108	94		253		115		105	27	
DAILY MEAN FLOWS (reported in cfs)												
TOTAL	2807	3693	4519	4199	4839	11430	11815	6955	4834	1877	2267	1298
MEAN	90.55	123.10	145.77	135.45	166.86	368.71	393.83	224.35	166.69	60.55	73.13	43.27
MAX	163	217	191	207	584	659	882	370	331	118	186	89
MIN	45	69	108	87	87	147	177	115	60	24	27	18
STD DEV	36.60	40.83	22.16	37.69	109.57	132.58	240.62	58.07	89.78	31.40	40.51	20.05
HISTORICAL RECORDS: 1928-1999 (MEAN DISCHARGES)												
MEAN	88.4	137	172	181	181	326	405	218	137	68.4	54	65
MAX	465	445	570	499	488	1066	963	438	503	337	319	893
MIN	7.86	13.9	29.1	17.2	37.5	118	129	73.8	18.2	9	4.94	6.12
REC. MAX?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
REC. MIN?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
HIGHEST DAILY MEAN?			882 cfs		26-Apr							
			8740 cfs		Sep 21 1938							
LOWEST DAILY MEAN?			18 cfs		12-Sep							
			0.46 cfs		Sep 15 1987							

01175500 SWIFT RIVER AT WEST WARE
WATER YEAR 2000 (OCT 1999 - SEP 2000)
PROVISIONAL DATA

DAY	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP
1	36	35	36	32	30	33	33	33	33	80	37	61
2	35	37	37	31	30	33	32	33	35	76	37	35
3	34	39	38	31	30	32	32	33	35	72	37	35
4	36	38	39	32	30	32	35	33	33	72	38	34
5	35	38	39	34	30	32	33	33	33	69	36	77
6	34	38	39	32	30	32	33	33	38	65	36	114
7	34	36	41	32	30	31	32	33	45	61	36	71
8	34	37	39	32	30	31	32	34	36	56	36	32
9	34	38	32	32	30	31	37	33	35	52	36	32
10	34	37	32	32	30	32	34	35	35	60	36	32
11	34	36	33	33	30	36	33	38	36	56	49	70
12	34	37	33	32	30	41	33	34	47	44	60	104
13	33	36	33	32	30	35	33	34	46	41	42	64
14	33	38	33	32	32	34	33	35	51	37	42	32
15	33	38	34	32	32	33	33	33	52	36	40	65
16	32	38	33	32	31	33	33	33	54	43	43	91
17	32	39	33	32	30	39	33	33	56	41	41	91
18	34	39	33	32	30	35	33	33	61	39	40	59
19	31	38	32	32	30	34	32	35	65	38	39	34
20	34	38	32	31	30	33	33	35	65	36	38	35
21	33	37	35	31	30	33	36	33	64	36	37	33
22	34	36	33	32	30	33	46	33	67	36	37	33
23	38	35	33	31	30	33	36	33	70	36	37	33
24	37	36	33	31	31	32	35	36	70	59	37	33
25	37	37	32	31	33	32	35	35	68	56	36	62
26	38	36	32	31	34	33	35	33	79	37	36	58
27	35	42	32	31	33	33	36	33	88	43	36	35
28	34	43	32	31	38	35	35	34	90	38	36	34
29	34	43	32	30	34	34	34	33	87	37	35	66
30	34	39	32	30		33	33	33	85	37	70	93
31	35		32	30		33		33		38	99	
DAILY MEAN FLOWS (reported in cfs)												
TOTAL	1065	1134	1059	979	898	1036	1023	1045	1659	1527	1295	1648
MEAN	34.35	37.80	34.16	31.58	30.97	33.42	34.10	33.71	55.30	49.26	41.77	54.93
MAX	**38**	**43**	**41**	**34**	**38**	**41**	**46**	**38**	**90**	**80**	**99**	**114**
MIN	31	35	32	30	30	31	32	33	33	36	35	32
STD DEV	1.62	2.01	2.78	0.85	1.86	2.14	2.64	1.19	18.78	14.18	12.96	25.10
HISTORICAL RECORDS: 1940-1999 (MEAN DISCHARGES)												
MEAN	72.3	78	74.2	73.8	79.5	85.6	174	167	128	77.2	79.1	79.5
MAX	222	858	656	572	467	511	1099	775	1192	301	149	139
MIN	30.3	31.3	28	27.5	27.6	27.7	26.2	27.4	28.6	31.2	30.7	30.3
REC. MAX?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
REC. MIN?	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO

HIGHEST DAILY MEAN?	114 cfs	6-Sep
	(3040 cfs	Jun 1 1984)
LOWEST DAILY MEAN?	30 cfs	Multiple
	(9.1 cfs	Dec 15 1968)

APPENDIX B

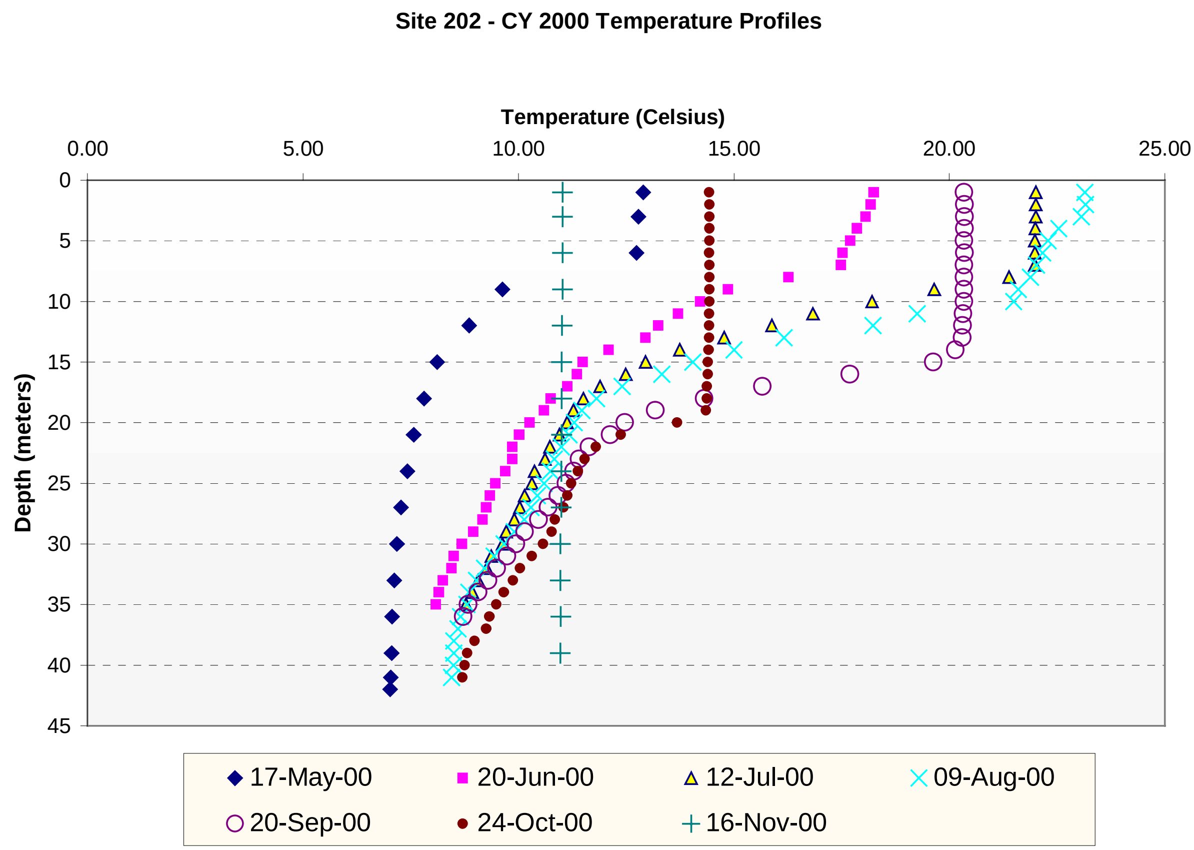
RESERVOIR PROFILES
FOR TEMPERATURE AND DISSOLVED OXYGEN

201 (WINSOR DAM)

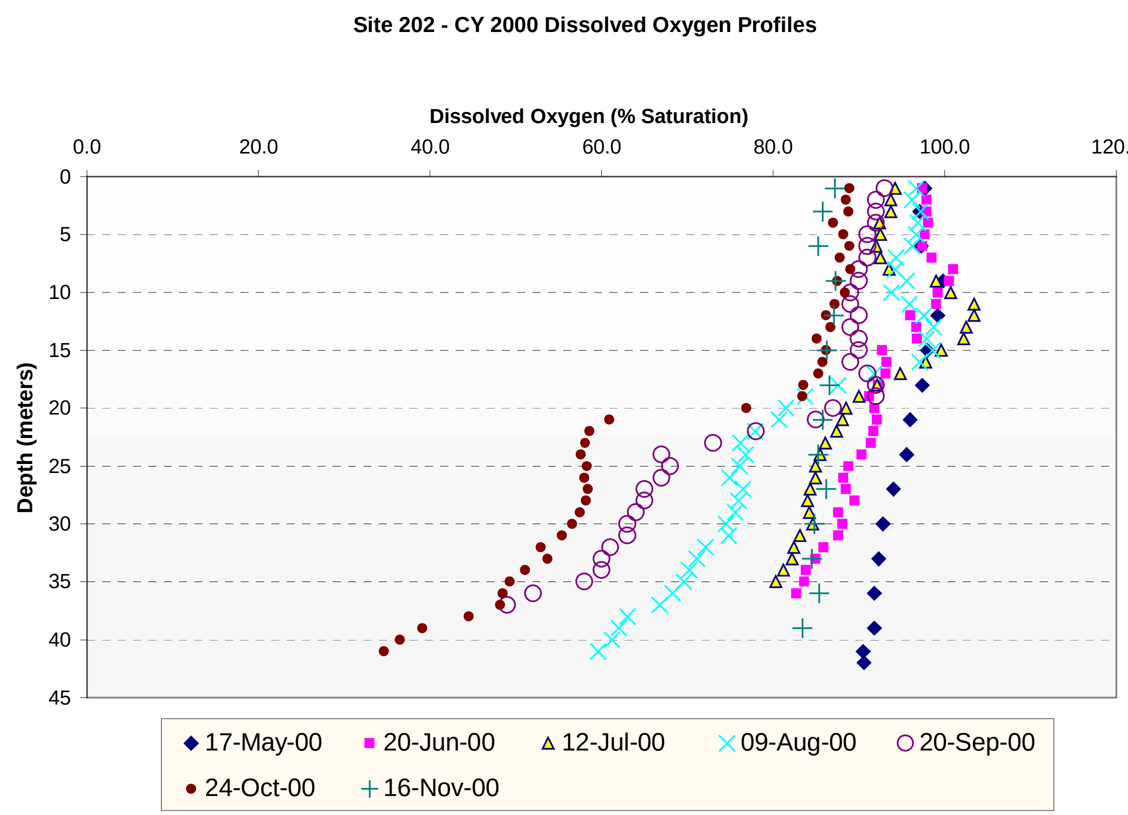
206 (SHAFT 12)

DEN HILL

DEN HILL AREA (WARE RIVER DIVERSIONS)

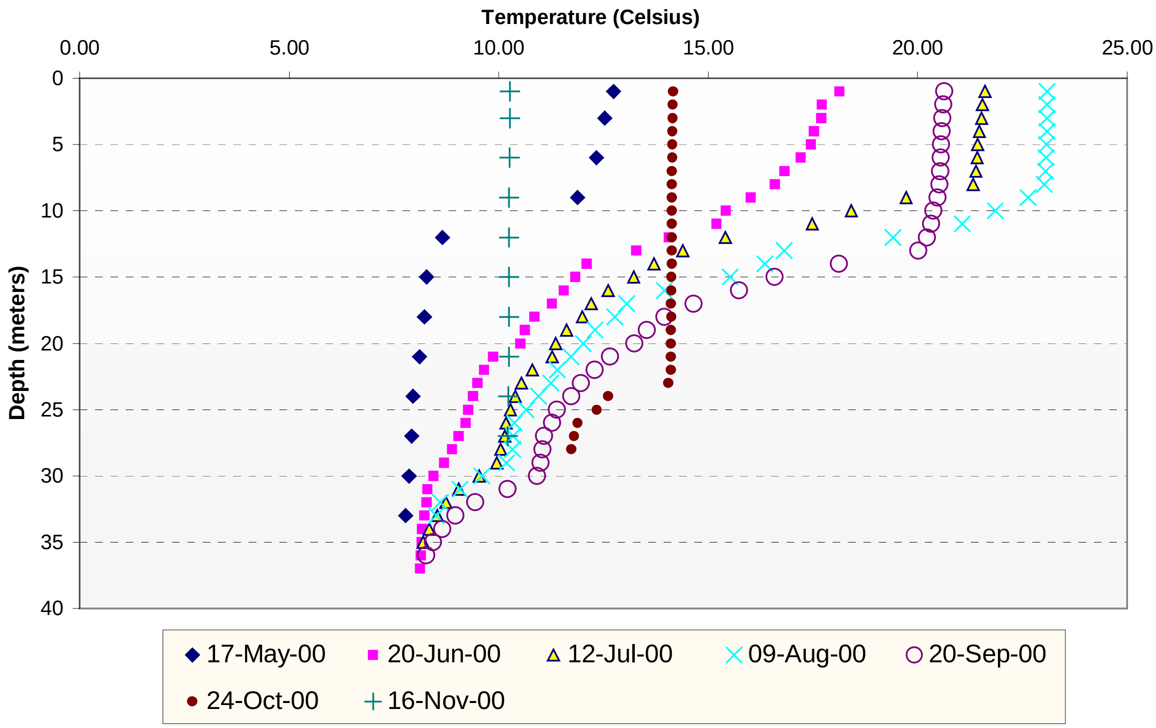


Site 202 - CY 2000 Temperature Profiles
Temperature (Celsius)
0.00
5.00
10.00
15.00
20.00
25.00
Depth (meters)
0
5
10
15
20
25
30
35
40
45
17-May-00
20-Jun-00
12-Jul-00
09-Aug-00
20-Sep-00
24-Oct-00
16-Nov-00

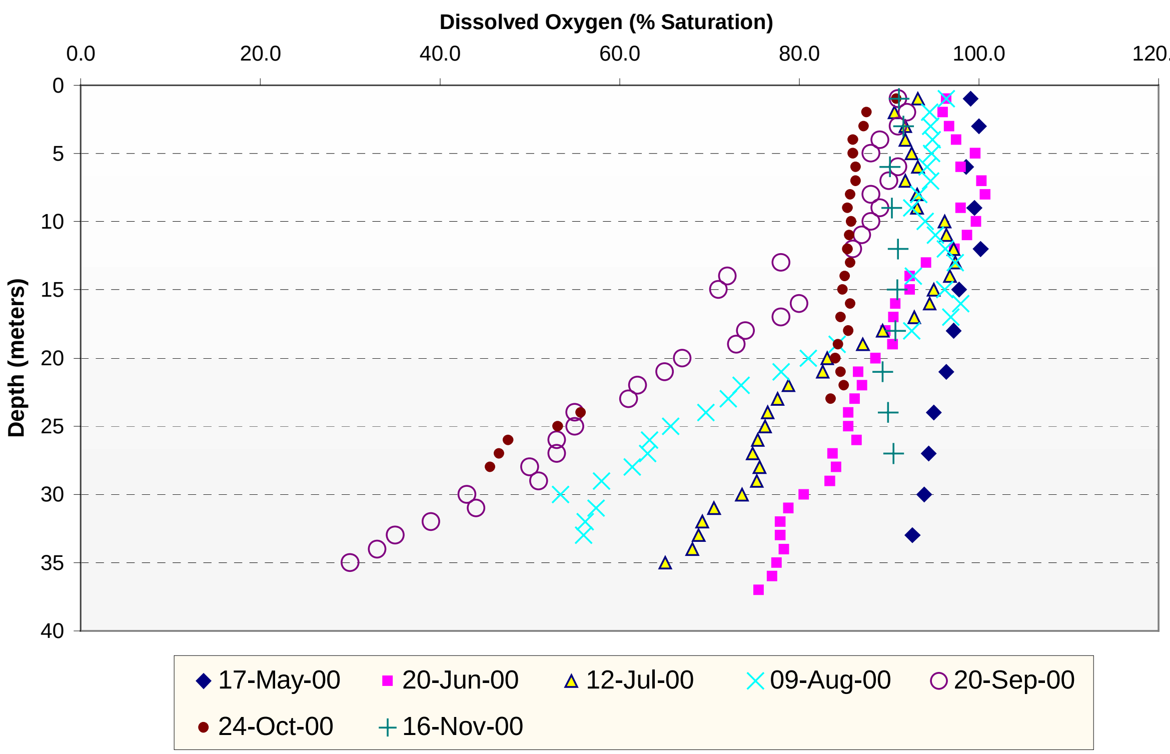


Site 202 - CY 2000 Dissolved Oxygen Profiles
Dissolved Oxygen (% Saturation)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
Depth (meters)
0
5
10
15
20
25
30
35
40
45
17-May-00
20-Jun-00
12-Jul-00
09-Aug-00
20-Sep-00
24-Oct-00
16-Nov-00

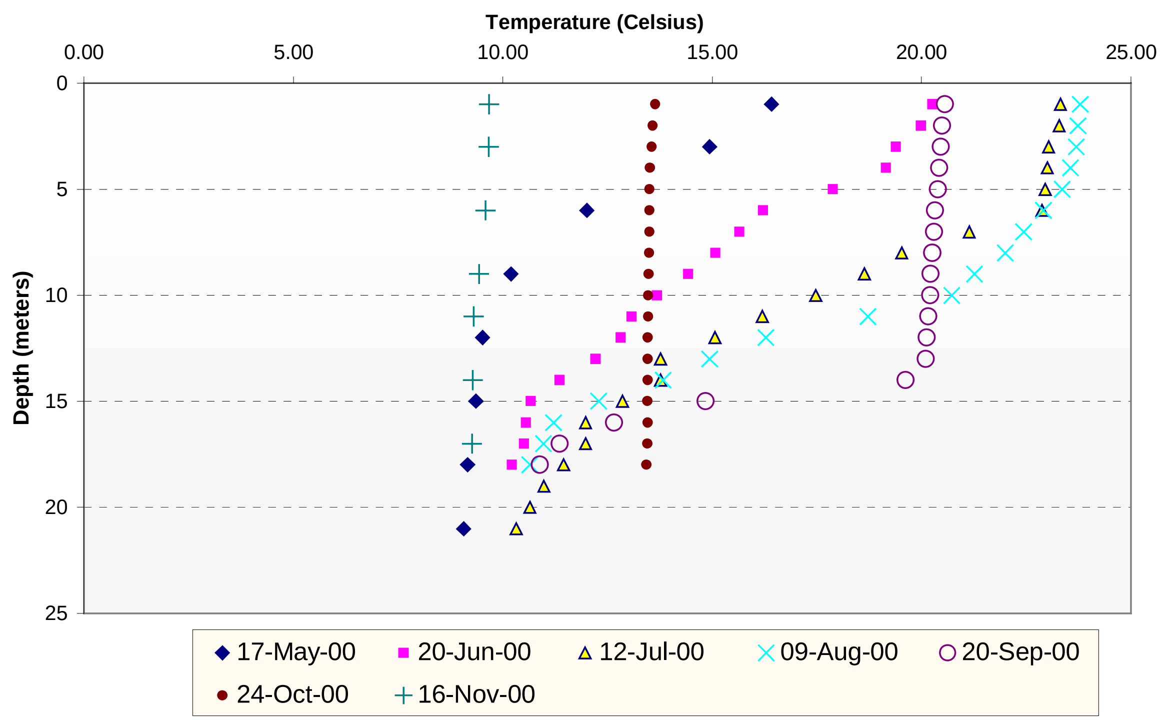
Site 206 (Shaft 12) - CY 2000 Temperature Profiles



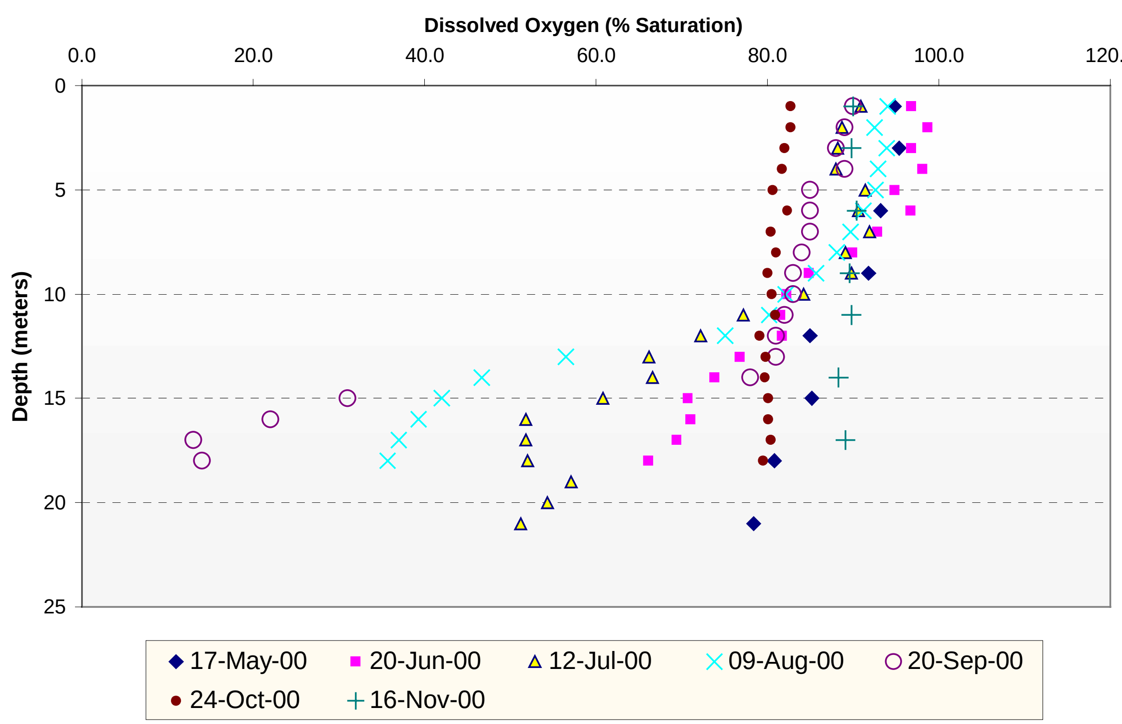
Site 206 (SHAFT 12) - CY 2000 Dissolved Oxygen Profiles



DEN HILL - CY 2000 Temperature Profiles



DEN HILL - CY 2000 Dissolved Oxygen Profiles



APPENDIX D

2000 WATER QUALITY DATA TABLES

Quabbin Reservoir Sample Stations

Quabbin Reservoir Special Samples

Quabbin Reservoir Sample Stations

QUABBIN LABORATORY RECORDS 2000
(202) WINSOR DAM -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH*	pH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV.
03/29	0.0															0	0	524.65
03/29	0.5		0.3	5	5.0	8.9	EE	6.61	3.9	2.5	12.56	100	3.55	0.03	38			
03/29	3.1						EE				12.56	100	3.53		38			
03/29	6.0						EE				12.44	99	3.50		38			
03/29	9.0						EE				12.45	99	3.48		38			
03/29	12.0						EE				12.55	100	3.48		38			
03/29	15.0						EE				12.53	100	3.48		38			
03/29	18.0						EE				12.55	100	3.50		38			
03/29	21.0						EE				12.50	100	3.51		38			
03/29	23.9						EE				12.40	99	3.54		38			
03/29	27.0						EE				12.53	100	3.56		38			
03/29	30.0						EE				12.50	100	3.56		38			
03/29	32.9						EE				12.46	99	3.58		38			
03/29	36.2						EE				12.47	100	3.59		38			
03/29	39.1		0.2	5	5.4	9.8	EE	6.58	4.0	2.6	12.52	100	3.62	0.04	38			
03/29	40.1	40.2					EE				12.53	100	3.68		38			
04/27	0.0															1	1	526.15
04/27	0.5		0.3	5	5.8	8.3		6.65	4.0	2.4				0.04				
04/27	3.0						EE				11.94	100	6.73		37			
04/27	6.0						EE				11.93	100	6.72		37			
04/27	9.0						EE				12.03	101	6.70		37			
04/27	12.0						EE				12.06	101	6.68		37			
04/27	15.0						EE				12.06	101	6.65		37			
04/27	18.0						EE				12.14	101	6.62		37			
04/27	21.0						EE				12.15	101	6.60		37			
04/27	24.0						EE				12.17	102	6.59		37			
04/27	27.0						EE				12.20	102	6.52		37			
04/27	30.0						EE				12.23	102	6.46		37			
04/27	32.0		0.3	5	6.0	9.0		6.62	4.0	2.4				0.03				
04/27	32.9	33.0					EE				12.30	102	6.41		37			
05/17	0.0															1	0	526.81
05/17	0.4		0.4	5	6.0	8.9	EE	6.58	3.9	2.4	10.10	98	12.90	0.03	38			
05/17	3.0						EE				10.07	97	12.78		39			
05/17	6.0						EE				10.10	97	12.74		38			
05/17	9.0						EE				11.12	100	9.63		38			
05/17	12.0						EE				11.26	99	8.86		38			
05/17	15.0						EE				11.33	98	8.11		38			
05/17	18.0						EE				11.34	97	7.81		38			
05/17	21.0						EE				11.24	96	7.57		38			
05/17	24.0						EE				11.23	96	7.42		38			
05/17	27.0						EE				11.08	94	7.28		38			
05/17	30.0						EE				10.98	93	7.18		38			
05/17	33.0						EE				10.94	92	7.12		38			
05/17	33.0						EE				10.93	92	7.11		38			
05/17	36.0						EE				10.88	92	7.07		38			
05/17	39.0						EE				10.88	92	7.06		38			
05/17	41.0		0.3	5	6.2	8.9	EE	6.42	3.9	2.4	10.75	91	7.03	0.03	38			
05/17	42.0	42.2					EE				10.75	91	7.02		38			
06/20	0.0															4	0	528.46
06/20	0.9						6.59				9.00	97	18.25		38			
06/20	1.9						6.63				9.07	98	18.17		38			
06/20	3.0						6.65				9.07	98	18.06		38			
06/20	4.0						6.66				9.13	98	17.86		38			
06/20	5.0		0.4	5	5.3	8.4	6.68	6.82	4.1	2.5	9.12	98	17.70	0.04	38			

QUABBIN LABORATORY RECORDS 2000
(202) WINSOR DAM -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH*	pH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV.
06/20	6.0						6.69				9.13	97	17.52		38			
06/20	7.1						6.69				9.25	99	17.48		38			
06/20	8.0						6.69				9.71	101	16.27		38			
06/20	9.0						6.70				9.96	101	14.87		38			
06/20	10.0						6.69				9.97	99	14.22		38			
06/20	11.0						6.63				10.07	99	13.70		38			
06/20	12.0						6.54				9.86	96	13.25		38			
06/20	11.8						6.53				9.93	97	13.24		38			
06/20	13.0						6.49				10.01	97	12.95		38			
06/20	14.0						6.29				9.77	93	12.09		39			
06/20	15.0						6.24				9.96	93	11.50		39			
06/20	16.0						6.19				9.97	93	11.36		39			
06/20	17.0						6.16				9.93	92	11.14		38			
06/20	17.9						6.14				9.91	91	10.75		39			
06/20	19.1						6.11				10.01	92	10.59		39			
06/20	20.0						6.09				10.13	92	10.26		39			
06/20	21.1						6.07				10.14	92	10.02		39			
06/20	22.1						6.06				10.14	91	9.86		39			
06/20	23.0		0.3	5	5.3	8.6	6.06	6.55	4.2	2.6	10.02	90	9.86	0.03	39			
06/20	24.0						6.04				9.90	89	9.69		39			
06/20	25.0						6.03				9.88	88	9.46		38			
06/20	26.0						6.03				9.94	89	9.34		38			
06/20	27.1						6.01				10.08	90	9.25		39			
06/20	28.0						6.00				9.89	88	9.17		39			
06/20	29.0						5.98				9.99	88	8.95		38			
06/20	30.0						5.96				10.00	88	8.69		39			
06/20	31.0						5.91				9.85	86	8.50		39			
06/20	32.0						5.90				9.74	85	8.45		39			
06/20	33.0						5.88				9.67	84	8.25		38			
06/20	34.1						5.84				9.66	84	8.16		38			
06/20	35.0	35.0					5.83				9.58	83	8.08		39			
07/12	0.0															3	0	528.17
07/12	1.0						6.46				7.99	94	22.01		39			
07/12	2.0						6.46				7.96	94	22.01		39			
07/12	3.0						6.46				7.96	94	22.01		39			
07/12	4.0						6.48				7.85	92	22.00		39			
07/12	5.0		0.3	5	6.5	8.1	6.48	6.77	4.0	2.5	7.85	93	21.99	0.03	39			
07/12	6.0						6.48				7.81	92	21.99		39			
07/12	7.0						6.48				7.86	93	21.99		39			
07/12	8.0						6.52				8.04	94	21.39		39			
07/12	9.0						6.55				8.81	99	19.65		38			
07/12	10.0						6.59				9.22	101	18.21		38			
07/12	11.0						6.66				9.74	103	16.83		38			
07/12	12.0						6.68				9.94	103	15.88		38			
07/12	13.0						6.68				10.09	103	14.77		38			
07/12	14.0						6.63				10.28	102	13.75		38			
07/12	15.0						6.55				10.20	100	12.95		38			
07/12	16.0						6.42				10.12	98	12.49		38			
07/12	17.0						6.28				9.95	95	11.89		38			
07/12	18.0						6.07				9.75	92	11.51		38			
07/12	19.0						5.99				9.57	90	11.28		38			
07/12	20.0						5.92				9.45	89	11.13		38			
07/12	21.0						5.88				9.45	88	10.95		38			
07/12	22.0						5.84				9.41	87	10.73		38			

QUABBIN LABORATORY RECORDS 2000
(202) WINSOR DAM -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH*	pH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV.
07/12	23.0						5.79				9.32	86	10.62		38			
07/12	24.0						5.75				9.29	86	10.38		38			
07/12	25.0		0.3	5	6.0	8.0	5.73	6.49	4.1	2.5	9.23	85	10.31	0.04	38			
07/12	26.0						5.71				9.27	85	10.14		38			
07/12	27.0						5.69				9.23	84	10.03		39			
07/12	28.0						5.68				9.23	84	9.90		38			
07/12	29.0						5.67				9.29	84	9.72		38			
07/12	30.0						5.67				9.35	85	9.63		38			
07/12	31.0						5.64				9.24	83	9.37		39			
07/12	32.0						5.62				9.19	82	9.26		39			
07/12	33.0						5.62				9.21	82	9.07		38			
07/12	34.0						5.60				9.12	81	8.93		38			
07/12	35.0	35.1					5.58				9.06	80	8.78		38			
08/09	0.0															100	0	527.82
08/09	1.0						6.48				8.04	97	23.15		39			
08/09	2.0						6.49				8.00	96	23.16		39			
08/09	3.0						6.50				8.10	97	23.06		39			
08/09	4.0						6.52				8.15	97	22.54		39			
08/09	5.0						6.50				8.17	97	22.29		39			
08/09	6.0		0.3	5	5.3	8.0	6.49	6.69	4.0	2.4	8.15	96	22.16	0.04	39	300	0	
08/09	7.0						6.47				8.01	94	22.03		40			
08/09	8.0						6.46				8.02	94	21.88		40			
08/09	9.0						6.42				8.19	96	21.60		40			
08/09	10.0						6.41				8.05	94	21.49		40			
08/09	11.0						6.31				8.61	96	19.25		40			
08/09	11.9						6.27				8.91	98	18.23		39			
08/09	13.0						6.24				9.44	99	16.16		39			
08/09	14.0						6.22				9.60	98	15.00		39			
08/09	15.0						6.19				9.87	99	14.05		39			
08/09	16.0						6.17				9.87	97	13.33		39			
08/09	16.9						5.98				9.53	92	12.41		39			
08/09	18.0						5.83				9.22	88	11.81		39			
08/09	19.1						5.72				8.88	84	11.47		39			
08/09	20.0						5.66				8.68	82	11.30		39			
08/09	21.0						5.62				8.62	81	11.17		39			
08/09	22.0						5.59				8.35	78	10.99		39			
08/09	23.0						5.56				8.20	76	10.84		39			
08/09	24.1						5.54				8.29	77	10.74		39			
08/09	25.0						5.54				8.23	76	10.59		40			
08/09	25.9						5.53				8.13	75	10.44		39			
08/09	27.0		0.6	5	5.2	7.8	5.53	6.31	4.1	2.5	8.34	77	10.29	0.03	40	480	0	
08/09	28.0						5.51				8.31	76	10.13		40			
08/09	29.0						5.50				8.32	76	9.90		40			
08/09	30.0						5.50				8.24	75	9.66		40			
08/09	31.0						5.48				8.31	75	9.43		40			
08/09	32.0						5.44				8.06	72	9.21		40			
08/09	33.0						5.42				7.99	71	9.02		40			
08/09	34.0						5.42				7.91	70	8.85		40			
08/09	35.0						5.41				7.86	70	8.80		40			
08/09	36.0						5.39				7.73	68	8.66		40			
08/09	37.0						5.37				7.58	67	8.60		40			
08/09	38.0						5.33				7.16	63	8.50		40			
08/09	39.0						5.33				7.05	62	8.50		40			
08/09	40.0						5.32				6.97	61	8.49		40			

QUABBIN LABORATORY RECORDS 2000
(202) WINSOR DAM -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH*	pH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV.
08/09	40.9	41.5					5.30				6.79	60	8.45		40			
09/20	0.0						EE				8.17	93	20.34		39	1400	2	527.05
09/20	1.0						EE				8.10	92	20.35		39			
09/20	2.0						EE				8.09	92	20.35		39			
09/20	3.0						EE				8.10	92	20.35		39			
09/20	4.0						EE				8.03	91	20.34		39			
09/20	5.0						EE				8.02	91	20.35		39			
09/20	6.0						EE				8.03	91	20.34		39			
09/20	7.0						EE				7.94	90	20.34		39			
09/20	8.0		0.3	5	5.5	7.2	EE	6.68	3.9	2.4	7.91	90	20.34	0.04	39			
09/20	9.0						EE				7.89	89	20.34		39			
09/20	10.0						EE				7.85	89	20.34		39			
09/20	11.0						EE				7.92	90	20.32		39			
09/20	12.0						EE				7.81	89	20.31		39			
09/20	13.0						EE				7.90	90	20.30		39			
09/20	14.0						EE				7.94	90	20.14		39			
09/20	15.0						EE				7.94	89	19.63		40			
09/20	16.0						EE				8.44	91	17.69		39			
09/20	17.0						EE				8.98	92	15.66		40			
09/20	18.0						EE				9.19	92	14.31		39	550	0	
09/20	19.0						EE				8.92	87	13.18		39			
09/20	20.0						EE				8.83	85	12.47		39			
09/20	21.0						EE				8.19	78	12.13		39			
09/20	22.0						EE				7.74	73	11.64		39			
09/20	23.0						EE				7.17	67	11.41		39			
09/20	24.0						EE				7.26	68	11.29		39			
09/20	25.0						EE				7.18	67	11.11		39			
09/20	26.0						EE				7.05	65	10.92		39			
09/20	27.0						EE				7.09	65	10.69		40			
09/20	28.1		0.3	5	5.7	7.4	EE	6.61	4.0	2.5	7.01	64	10.47	0.03	40			
09/20	29.0						EE				6.96	63	10.14		40			
09/20	30.0						EE				6.93	63	9.95		40			
09/20	31.0						EE				6.81	61	9.74		40			
09/20	32.0						EE				6.72	60	9.50		40			
09/20	33.0						EE				6.67	60	9.30		40			
09/20	34.0						EE				6.50	58	9.07		40			
09/20	35.0						EE				5.93	52	8.84		40			
09/20	36.0	36.5					EE				5.54	49	8.72		40			
10/24	0.0															387	0	525.89
10/24	1.0						EE				9.03	89	14.43		39			
10/24	2.0						EE				8.99	89	14.44		39			
10/24	3.0						EE				9.03	89	14.44		40			
10/24	4.0						EE				8.84	87	14.44		39			
10/24	5.0						EE				8.97	88	14.44		39			
10/24	5.9						EE				9.04	89	14.43		39			
10/24	7.0						EE				8.92	88	14.44		39			
10/24	8.0						EE				9.05	89	14.44		40			
10/24	9.0						EE				8.89	88	14.44		40			
10/24	10.0						EE				8.98	88	14.44		39			
10/24	11.0		0.3	5	5.6	7.6	EE	6.68	4.3	2.7	8.87	87	14.43	0.04	40			
10/24	12.0						EE				8.76	86	14.43		40			
10/24	13.0						EE				8.81	87	14.43		40			
10/24	14.0						EE				8.65	85	14.42		40			
10/24	15.0						EE				8.77	86	14.39		40			

QUABBIN LABORATORY RECORDS 2000
(202) WINSOR DAM -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH*	pH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV.
10/24	16.0						EE				8.73	86	14.39		40			
10/24	17.0						EE				8.69	85	14.37		40			
10/24	18.0						EE				8.51	84	14.37		40	600	0	
10/24	19.0						EE				8.50	83	14.35		40			
10/24	20.0						EE				7.94	77	13.68		40			
10/24	21.0						EE				6.48	61	12.37		40			
10/24	22.0						EE				6.32	59	11.80		40			
10/24	23.0						EE				6.28	58	11.54		40			
10/24	24.0						EE				6.28	58	11.38		40			
10/24	25.0						EE				6.37	58	11.22		40			
10/24	26.0						EE				6.35	58	11.14		40			
10/24	27.1						EE				6.40	58	11.05		40			
10/24	28.0						EE				6.41	58	10.85		40			
10/24	29.0						EE				6.35	58	10.77		40			
10/24	30.0						EE				6.28	57	10.57		40			
10/24	31.0		0.2	5	6.0	7.5	EE	6.11	4.3	2.6	6.18	55	10.31	0.04	40			
10/24	32.0						EE				5.94	53	10.04		40			
10/24	33.1						EE				6.05	54	9.87		40			
10/24	34.0						EE				5.79	51	9.66		40			
10/24	35.0						EE				5.61	49	9.49		41			
10/24	36.0						EE				5.54	49	9.33		40			
10/24	37.0						EE				5.51	48	9.25		41			
10/24	38.0						EE				5.12	45	8.98		41			
10/24	39.0						EE				4.52	39	8.82		41			
10/24	40.0						EE				4.22	37	8.75		41			
10/24	41.0	41.2					EE				4.01	35	8.70		42			
11/16	0.0															8	0	525.37
11/16	1.0		0.3	5	5.2	7.3	EE	6.65	4.1	2.5	9.29	87	11.02	0.03	39			
11/16	3.0						EE				9.14	86	11.02		39			
11/16	6.0						EE				9.09	85	11.02		39			
11/16	9.1						EE				9.31	87	11.02		40			
11/16	12.2						EE				9.29	87	11.01		40			
11/16	15.0						EE				9.20	86	11.00		40			
11/16	17.9						EE				9.23	87	11.00		40			
11/16	21.0						EE				9.15	86	11.00		40			
11/16	23.9						EE				9.10	85	10.99		40			
11/16	27.1						EE				9.20	86	10.99		40			
11/16	30.0						EE				9.04	85	10.97		40			
11/16	33.0		0.4	5	5.9	7.5	EE	6.57	4.1	2.5	9.02	85	10.97	0.03	40	8	0	
11/16	36.0						EE				9.11	85	10.98		40			
11/16	38.9	38.9					EE				8.97	83	10.97		40			
	AVG.		0.3	5	5.7	8.2		6.58	4.1	2.5	9.01	85	12.10	0.03	39	274	0	526.71
	MAX.		0.6	5	6.5	9.8		6.82	4.3	2.7	12.56	103	23.16	0.04	42	1400	2	528.46
	MIN.		0.2	5	5.0	7.2		6.11	3.9	2.4	4.01	35	3.48	0.03	37	0	0	524.65
	MEDIAN		0.3	5	5.7	8.1		6.61	4.0	2.5	9.04	89	10.99	0.03	39	54	0	526.81

EE= EQUIPMENT ERROR
*LISTED pH DATA TAKEN BY FIELD INSTRUMENT IS CONSISTENTLY LOWER THAN IN-LAB pH ANALYSIS.

QUABBIN LABORATORY RECORDS 2000
(206) SHAFT #12 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	PH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
03/29	0.0		0.3	5	5.1	8.0		6.61	3.9	2.5				0.04		0	0	524.65
03/29	3.0						EE				12.65	102	3.87		38			
03/29	6.0						EE				12.63	102	3.87		38			
03/29	9.1						EE				12.65	102	3.85		38			
03/29	12.1						EE				12.66	102	3.83		38			
03/29	15.0						EE				12.58	101	3.83		38			
03/29	17.7						EE				12.59	101	3.83		38			
03/29	21.0						EE				12.63	101	3.82		38			
03/29	23.9						EE				12.64	102	3.81		38			
03/29	27.1						EE				12.65	102	3.81		38			
03/29	30.2						EE				12.77	103	3.82		38			
03/29	32.7		0.3	5	5.4	10.1	EE	6.57	3.8	2.4	12.75	102	3.81	0.04	38			
03/29	33.4						EE				12.75	102	3.79		38			
04/27	0.0															0	0	526.15
04/27	0.5		0.3	5	5.7	10.0		6.63	4.1	2.5				0.03				
04/27	3.0						EE				12.06	101	6.60		37			
04/27	6.1						EE				12.11	101	6.59		37			
04/27	9.0						EE				12.12	101	6.57		37			
04/27	12.0						EE				12.10	101	6.54		37			
04/27	15.0						EE				12.11	101	6.52		37			
04/27	18.0						EE				12.03	100	6.49		37			
04/27	20.9						EE				12.07	101	6.46		37			
04/27	24.0						EE				12.06	100	6.46		37			
04/27	27.0						EE				12.07	100	6.47		37			
04/27	30.0						EE				12.17	101	6.47		37			
04/27	33.0	34.0	0.4	5	5.8	9.9	EE	6.62	4.1	2.5	12.16	101	6.46	0.04	37			
05/17	0.0															0	0	526.81
05/17	0.5		0.3	5	6.5	8.8	EE	6.64	4.1	2.6	10.28	99	12.74	0.03	39			
05/17	3.2						EE				10.43	100	12.53		39			
05/17	6.0						EE				10.32	99	12.33		39			
05/17	9.0						EE				10.53	100	11.88		39			
05/17	12.0						EE				11.43	100	8.66		38			
05/17	15.0						EE				11.26	98	8.28		38			
05/17	18.0						EE				11.20	97	8.23		38			
05/17	21.0						EE				11.15	96	8.11		38			
05/17	24.0						EE				11.02	95	7.96		38			
05/17	27.0						EE				10.96	94	7.93		38			
05/17	30.0						EE				10.91	94	7.86		38			
05/17	32.0		0.3	5	6.5	9.9		6.52	4.0	2.5				0.04				
05/17	33.0	34.0					EE				10.79	93	7.78		38			
06/20	0.0															0	0	528.46
06/20	1.0						6.58				8.92	96	18.13		39			
06/20	2.0						6.63				8.96	96	17.71		39			
06/20	3.1						6.65				9.02	97	17.70		39			
06/20	4.1						6.71				9.14	98	17.53		39			
06/20	4.9						6.71				9.35	100	17.45		38			

QUABBIN LABORATORY RECORDS 2000
(206) SHAFT #12 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	PH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
06/20	6.0		0.4	5	5.4	8.7	6.75	6.83	4.1	2.6	9.25	98	17.21	0.03	39			
06/20	7.0						6.75				9.53	100	16.82		39			
06/20	8.0						6.75				9.62	101	16.59		39			
06/20	9.0						6.76				9.48	98	16.02		39			
06/20	10.1						6.75				9.76	100	15.42		39			
06/20	11.0						6.72				9.71	99	15.20		39			
06/20	12.1						6.65				9.75	97	14.06		38			
06/20	13.0						6.53				9.66	94	13.29		39			
06/20	14.3						6.40				9.73	92	12.10		39			
06/20	15.0						6.34				9.79	92	11.83		39			
06/20	16.0						6.24				9.67	91	11.56		39			
06/20	17.0						6.20				9.71	91	11.27		39			
06/20	18.6						6.16				9.69	90	10.86		39			
06/20	19.1						6.10				9.86	90	10.63		39			
06/20	20.0						6.07				9.68	89	10.52		39			
06/20	21.0						6.02				9.62	87	9.87		39			
06/20	22.0						5.98				9.71	87	9.65		39			
06/20	23.0						5.96				9.66	86	9.50		38			
06/20	24.0						5.94				9.59	86	9.39		38			
06/20	25.0		0.3	5	5.5	8.5	5.93	6.47	4.2	2.6	9.62	86	9.28	0.03	39			
06/20	26.0						5.93				9.74	86	9.21		38			
06/20	27.0						5.88				9.47	84	9.04		39			
06/20	28.0						5.86				9.56	84	8.89		39			
06/20	29.1						5.84				9.51	83	8.70		38			
06/20	30.0						5.81				9.24	81	8.45		39			
06/20	31.0						5.77				9.07	79	8.30		39			
06/20	32.0						5.76				8.99	78	8.28		39			
06/20	33.0						5.75				8.99	78	8.23		39			
06/20	34.0						5.76				9.06	78	8.18		39			
06/20	34.0						5.75				8.95	78	8.17		39			
06/20	35.0						5.73				8.91	77	8.15		39			
06/20	35.7	36.0					5.73				8.73	76	8.12		39			
07/12	0.0															0	0	528.17
07/12	1.0						6.40				7.98	93	21.61		39			
07/12	2.0						6.42				7.76	91	21.55		39			
07/12	3.0						6.44				7.87	92	21.52		39			
07/12	4.0						6.45				7.87	92	21.47		39			
07/12	5.0		0.4	5	6.0	8.1	6.46	6.79	4.0	2.5	7.93	93	21.43	0.04	39			
07/12	6.0						6.47				8.00	93	21.42		39			
07/12	7.1						6.47				7.89	92	21.39		39			
07/12	8.0						6.48				8.01	93	21.33		39			
07/12	9.0						6.49				8.27	93	19.72		39			
07/12	10.0						6.43				8.76	96	18.42		39			
07/12	11.0						6.41				8.96	96	17.48		39			
07/12	12.0						6.38				9.43	97	15.41		39			
07/12	13.0						6.37				9.66	97	14.39		39			

QUABBIN LABORATORY RECORDS 2000
(206) SHAFT #12 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	PH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
07/12	14.0						6.35				9.75	97	13.70		38			
07/12	15.0						6.31				9.67	95	13.22		38			
07/12	16.0						6.24				9.75	95	12.61		38			
07/12	17.0						6.11				9.66	93	12.21		38			
07/12	18.0						6.00				9.35	89	12.00		38			
07/12	19.0						5.91				9.19	87	11.62		38			
07/12	20.0						5.78				8.82	83	11.36		38			
07/12	21.0						5.74				8.79	83	11.28		38			
07/12	22.0						5.66				8.47	79	10.80		39			
07/12	23.0						5.63				8.41	78	10.54		39			
07/12	24.0		0.3	5	6.1	8.2	5.60	6.35	4.0	2.5	8.30	77	10.40	0.03	38			
07/12	25.0						5.58				8.29	76	10.28		39			
07/12	26.0						5.56				8.22	75	10.18		39			
07/12	27.0						5.55				8.17	75	10.14		39			
07/12	28.0						5.55				8.27	76	10.05		39			
07/12	29.0						5.54				8.26	75	9.96		39			
07/12	30.0						5.53				8.15	74	9.54		39			
07/12	30.9						5.48				7.91	71	9.05		39			
07/12	32.0						5.46				7.82	69	8.74		39			
07/12	33.0						5.46				7.81	69	8.53		39			
07/12	34.0						5.44				7.76	68	8.34		39			
07/12	35.0	35.0					5.42				7.45	65	8.20		39			
08/09	0.0															180	0	527.82
08/09	1.0						6.37				8.03	96	23.08		40			
08/09	2.0						6.42				7.87	95	23.08		40			
08/09	3.0						6.45				7.88	95	23.08		40			
08/09	4.1						6.46				7.89	95	23.08		40			
08/09	5.0						6.49				7.89	95	23.07		40			
08/09	6.0		0.2	5	5.4	7.2	6.50	6.67	4.0	2.4	7.85	94	23.06	0.04	40	300	0	
08/09	7.0						6.52				7.88	95	23.05		40			
08/09	8.0						6.52				7.78	93	23.02		40			
08/09	9.0						6.52				7.77	93	22.63		40			
08/09	9.9						6.47				8.01	94	21.85		40			
08/09	11.0						6.41				8.24	95	21.06		40			
08/09	12.0						6.28				8.61	96	19.41		40			
08/09	13.0						6.20				9.19	97	16.81		40			
08/09	14.0						6.05				8.83	93	16.35		40			
08/09	15.0						6.09				9.33	96	15.53		40			
08/09	16.0						6.17				9.83	98	13.96		39			
08/09	17.1						6.17				9.91	97	13.06		39			
08/09	18.0						6.02				9.52	93	12.77		39			
08/09	19.0						5.78				8.76	84	12.30		39			
08/09	20.0						5.67				8.48	81	12.02		39			
08/09	21.0						5.61				8.24	78	11.73		40			
08/09	22.1		0.3	5	5.2	7.4	5.54	6.32	4.1	2.5	7.81	74	11.40	0.03	40	160	0	
08/09	23.0						5.51				7.68	72	11.24		40			

QUABBIN LABORATORY RECORDS 2000
(206) SHAFT #12 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	PH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
08/09	24.0						5.47				7.47	70	10.95		40			
08/09	25.0						5.43				7.10	66	10.66		40			
08/09	26.0						5.41				6.89	63	10.37		40			
08/09	26.9						5.40				6.87	63	10.34		40			
08/09	28.0						5.39				6.68	61	10.33		40			
08/09	29.0						5.37				6.34	58	10.19		40			
08/09	30.0						5.35				5.91	53	9.60		41			
08/09	30.9						5.36				6.44	57	9.08		40			
08/09	32.0						5.32				6.37	56	8.61		40			
08/09	33.0	33.4					5.31				6.37	56	8.51		40			
09/20	0.0						EE				8.19	93	20.63		40	150	0	527.05
09/20	1.1						EE				8.00	91	20.61		40			
09/20	2.0						EE				8.03	92	20.59		40			
09/20	3.0						EE				8.00	91	20.57		40			
09/20	4.0						EE				7.78	89	20.56		40			
09/20	5.0						EE				7.77	88	20.55		40			
09/20	6.0						EE				7.96	91	20.54		40			
09/20	7.0		0.3	5	5.7	7.2	EE	6.69	3.9	2.4	7.89	90	20.52	0.03	40			
09/20	8.0						EE				7.76	88	20.48		40			
09/20	9.0						EE				7.85	89	20.37		40			
09/20	10.0						EE				7.74	88	20.32		40			
09/20	11.0						EE				7.72	87	20.23		40			
09/20	12.0						EE				7.66	86	20.02		40			
09/20	13.0						EE				7.24	78	18.12		40			
09/20	14.0						EE				6.89	72	16.58		40			
09/20	15.0						EE				6.92	71	15.74		40			
09/20	16.0						EE				7.99	80	14.66		40			
09/20	17.0						EE				7.81	78	13.95		40			
09/20	18.0						EE				7.55	74	13.54		40			
09/20	19.0						EE				7.45	73	13.24		40			
09/20	20.0						EE				6.93	67	12.66		40			
09/20	21.0						EE				6.75	65	12.29		40			
09/20	22.0						EE				6.55	62	11.97		40			
09/20	23.0						EE				6.49	61	11.74		40			
09/20	24.0						EE				5.93	55	11.39		40	0	0	
09/20	25.0						EE				5.91	55	11.28		40			
09/20	26.0		0.4	5	6.0	7.5	EE	6.17	4.2	2.7	5.74	53	11.09	0.04	40			
09/20	27.0						EE				5.73	53	11.05		40			
09/20	28.0						EE				5.43	50	11.00		41			
09/20	29.0						EE				5.50	51	10.92		41			
09/20	30.0						EE				4.68	43	10.22		41			
09/20	31.0						EE				4.87	44	9.44		40			
09/20	32.0						EE				4.41	39	8.97		41			
09/20	33.0						EE				3.94	35	8.66		41			
09/20	34.0						EE				3.73	33	8.44		41			
09/20	35.0	35.2					EE				3.41	30	8.27		41			

QUABBIN LABORATORY RECORDS 2000
(206) SHAFT #12 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	PH-LAB	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
10/24	0.0															8	0	525.89
10/24	1.0						EE				9.29	91	14.16		40			
10/24	2.0						EE				8.96	88	14.15		40			
10/24	3.0						EE				8.92	87	14.15		40			
10/24	4.0						EE				8.80	86	14.14		40			
10/24	5.0						EE				8.80	86	14.14		40			
10/24	6.0						EE				8.83	86	14.14		40			
10/24	7.0						EE				8.84	86	14.13		40			
10/24	8.0						EE				8.77	86	14.13		40			
10/24	9.0						EE				8.76	85	14.13		40			
10/24	10.0						EE				8.78	86	14.13		40			
10/24	11.0						EE				8.76	86	14.13		40			
10/24	12.0		0.3	5	6.0	7.5	EE	6.61	4.3	2.7	8.74	85	14.13	0.05	40			
10/24	13.0						EE				8.77	86	14.13		40			
10/24	14.0						EE				8.71	85	14.13		40			
10/24	15.0						EE				8.68	85	14.12		40			
10/24	16.0						EE				8.77	86	14.12		40			
10/24	17.0						EE				8.67	85	14.11		40			
10/24	17.9						EE				8.75	86	14.12		40			
10/24	19.0						EE				8.63	84	14.11		40			
10/24	20.1						EE				8.61	84	14.11		40			
10/24	21.0						EE				8.66	85	14.11		40			
10/24	22.0						EE				8.70	85	14.11		40			
10/24	23.0						EE				8.56	84	14.05		40			
10/24	24.0						EE				5.90	56	12.61		41	11	0	
10/24	25.1						EE				5.65	53	12.34		41			
10/24	26.0		0.3	7	5.7	7.6	EE	6.14	4.6	2.9	5.13	48	11.88	0.08	41			
10/24	27.0						EE				5.02	47	11.80		41			
10/24	28.1	28.8					EE				4.92	46	11.74		41			
11/16	0.0															11	1	525.37
11/16	1.0		0.3	5	5.5	7.3	EE	6.66	4.2	2.6	9.88	91	10.27	0.04	39			
11/16	3.0						EE				9.93	92	10.27		39			
11/16	6.0						EE				9.77	90	10.26		39			
11/16	8.9						EE				9.79	90	10.25		39			
11/16	11.9						EE				9.87	91	10.25		40			
11/16	15.1						EE				9.87	91	10.25		39			
11/16	18.0						EE				9.85	91	10.25		40			
11/16	21.0						EE				9.69	89	10.25		39			
11/16	24.1						EE				9.76	90	10.23		40	9	0	
11/16	27.0	28.9	0.3	5	6.0	7.6	EE	6.68	4.2	2.6	9.83	91	10.22	0.03	40			
	AVG.		0.3	5	5.8	8.3		6.55	4.1	2.6	8.82	84	12.65	0.04	39	59	0	526.71
	MAX.		0.4	7	6.5	10.1		6.83	4.6	2.9	12.77	103	23.08	0.08	41	300	1	528.46
	MIN.		0.2	5	5.1	7.2		6.14	3.8	2.4	3.41	30	3.79	0.03	37	0	0	524.65
	MEDIAN		0.3	5	5.7	8.1		6.62	4.1	2.5	8.77	89	11.77	0.04	39	9	0	526.81

EE= EQUIPMENT ERROR

LISTED pH DATA TAKEN BY FIELD INSTRUMENT IS CONSISTENTLY LOWER THAN IN-LAB pH ANALYSIS.

QUABBIN LABORATORY RECORDS 2000
DEN HILL -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	Ph-lab	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
03/29	0.0		0.4	13	8.1	9.2		6.37	3.9	2.5				0.10		2	0	524.65
03/29	2.7						EE				11.75	98	5.45		45			
03/29	6.5						EE				11.75	99	5.45		46			
03/29	9.0						EE				11.76	98	5.42		45			
03/29	12.5						EE				11.75	98	5.29		45			
03/29	15.3						EE				11.69	97	5.13		45			
03/29	17.2		0.4	13	7.9	9.3	EE	6.35	3.9	2.5	11.68	96	4.89	0.12	45			
03/29	18.1	18.2					EE				11.69	96	4.85		45			
04/06	1.9						EE				12.07	102	6.31		45			524.94
04/06	4.0						EE				12.12	101	6.30		45			
04/06	6.0						EE				11.98	101	6.29		45			
04/06	8.0						EE				11.86	100	6.29		45			
04/06	10.0						EE				11.87	100	6.29		45			
04/06	12.0						EE				11.94	100	6.22		45			
04/06	14.0						EE				11.82	99	6.19		45			
04/06	16.0						EE				11.81	99	6.20		45			
04/06	18.0						EE				11.73	98	6.19		45			
04/13	3.0						6.40				11.06	93	7.09		45			525.33
04/13	5.0						6.39				11.09	93	7.06		45			
04/13	7.0						6.38				10.92	92	7.09		45			
04/13	9.0						6.39				11.01	93	7.08		45			
04/13	11.1						6.36				11.08	93	7.00		45			
04/13	13.0						6.37				10.78	91	6.99		45			
04/13	14.9						6.41				10.91	92	6.97		45			
04/13	17.0						6.36				10.97	92	6.96		45			
04/27	0.0															1	0	526.15
04/27	0.5		0.4	10	7.4	9.8		6.56	4.1	2.5				0.06				
04/27	3.0						6.31				11.05	97	8.66		43			
04/27	6.0						6.34				11.21	98	8.52		44			
04/27	9.0						6.35				11.11	97	8.48		44			
04/27	12.0						6.36				11.08	97	8.45		44			
04/27	15.0						6.36				11.10	97	8.44		44			
04/27	18.0	19.2	0.4	12	7.9	10.0	6.37	6.53	4.1	2.6	11.13	97	8.43	0.08	44			
05/17	0.0															0	0	526.81
05/17	0.6		0.4	10	8.2	10.5	6.64	6.57	3.9	2.4	9.25	95	16.42	0.05	43			
05/17	3.0						6.45				9.43	95	14.94		44			
05/17	6.0						6.33				9.83	93	12.01		43			
05/17	9.1						6.26				10.10	92	10.20		43			
05/17	12.0						6.08				9.50	85	9.52		43			
05/17	15.0						6.05				9.56	85	9.36		43			
05/17	18.0		0.4	10	8.4	12.2	5.95	6.42	4.1	2.7	9.11	81	9.16	0.07	44			
05/17	19.0	19.2					5.91				8.85	78	9.07		44			
06/20	0.0															0	0	528.46
06/20	1.0						6.55				8.58	97	20.26		42			
06/20	2.0						6.57				8.81	99	19.99		42			
06/20	2.9						6.63				8.73	97	19.39		41			
06/20	4.1		0.4	8	7.9	8.9	6.64	6.85	4.2	2.5	8.89	98	19.15	0.05	41			
06/20	5.0						6.56				8.82	95	17.88		41			
06/20	6.0						6.56				9.36	97	16.22		40			
06/20	7.0						6.42				9.04	93	15.65		40			
06/20	8.0						6.30				8.87	90	15.08		40			
06/20	9.0						6.13				8.48	85	14.43		41			
06/20	10.0						5.97				8.36	82	13.68		41			

QUABBIN LABORATORY RECORDS 2000
DEN HILL -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	Ph-lab	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
06/20	11.0						5.94				8.40	82	13.08		41			
06/20	12.1						5.90				8.47	82	12.81		41			
06/20	13.0						5.82				8.07	77	12.22		42			
06/20	14.0		0.3	10	7.9	9.3	5.75	6.33	4.2	2.6	7.91	74	11.36	0.04	42			
06/20	15.0						5.69				7.70	71	10.67		43			
06/20	16.0						5.66				7.75	71	10.55		43			
06/20	17.1						5.64				7.59	69	10.51		43			
06/20	18.0	18.7					5.61				7.27	66	10.22		44			
07/12	0.0															2	0	528.17
07/12	1.0						6.37				7.53	91	23.31		41			
07/12	2.0						6.39				7.35	89	23.28		41			
07/12	3.0						6.43				7.34	88	23.03		41			
07/12	4.0		0.4	8	7.1	8.2	6.44	6.79	4.1	2.4	7.33	88	23.00	0.04	41			
07/12	5.1						6.46				7.62	91	22.95		41			
07/12	6.0						6.49				7.56	91	22.87		41			
07/12	7.0						6.36				7.94	92	21.14		40			
07/12	8.0						6.22				7.93	89	19.52		40			
07/12	9.0						6.13				8.13	90	18.64		40			
07/12	10.0						5.98				7.83	84	17.47		41			
07/12	11.0						5.81				7.37	77	16.20		41			
07/12	12.0						5.70				7.06	72	15.06		41			
07/12	13.0						5.56				6.66	66	13.77		41			
07/12	13.0						5.56				6.70	67	13.77		41			
07/12	14.0		0.4	8	7.1	8.2	5.47	6.31	4.2	2.6	6.24	61	12.86	0.04	42			
07/12	15.0						5.39				5.42	52	11.98		43			
07/12	15.1						5.37				5.43	52	11.98		43			
07/12	16.0						5.36				5.51	52	11.45		43			
07/12	17.0						5.38				6.12	57	10.98		43			
07/12	18.0						5.36				5.86	54	10.65		44			
07/12	19.0	19.8					5.35				5.56	51	10.32		44			
08/09	0.0															9500	0	527.82
08/09	1.0						6.35				7.72	94	23.79		41			
08/09	2.0						6.38				7.61	93	23.73		41			
08/09	3.0						6.42				7.73	94	23.69		41			
08/09	4.0						6.44				7.66	93	23.56		41			
08/09	5.0						6.44				7.67	93	23.36		41			
08/09	6.0		0.3	8	5.5	7.6	6.37	6.71	4.2	2.6	7.62	91	22.91	0.04	41			
08/09	7.0						6.29				7.56	90	22.44		41			
08/09	8.0						6.20				7.49	88	22.00		41			
08/09	9.1						6.13				7.39	86	21.26		41			
08/09	10.0						5.95				7.15	82	20.72		41			
08/09	11.1						5.83				7.28	80	18.72		41			
08/09	12.0						5.73				7.17	75	16.28		42			
08/09	13.0						5.50				5.54	57	14.94		42			
08/09	14.0						5.39				4.69	47	13.83		43			
08/09	15.0		0.5	10	6.4	7.9	5.33	6.15	4.4	2.7	4.37	42	12.29	0.10	44			
08/09	15.9						5.30				4.20	39	11.21		44			
08/09	17.0						5.27				3.97	37	10.97		45			
08/09	18.0	18.9					5.26				3.86	36	10.65		45			
09/20	0.0						EE				7.97	92	21.49		40	60	0	527.05
09/20	1.0						EE				7.92	90	20.56		40			
09/20	2.0						EE				7.81	89	20.49		40			
09/20	3.0						EE				7.77	88	20.46		40			

QUABBIN LABORATORY RECORDS 2000
DEN HILL -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	Ph-lab	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
09/20	4.0						EE				7.84	89	20.43		40			
09/20	5.0						EE				7.53	85	20.39		40			
09/20	6.0						EE				7.48	85	20.32		41			
09/20	7.0						EE				7.52	85	20.30		41			
09/20	8.0		0.3	8	6.0	7.3	EE	6.65	4.2	2.6	7.44	84	20.26	0.05	41			
09/20	9.0						EE				7.33	83	20.22		41			
09/20	10.0						EE				7.37	83	20.21		41			
09/20	11.0						EE				7.22	82	20.16		41			
09/20	12.0						EE				7.18	81	20.12		41			
09/20	13.0						EE				7.19	81	20.10		41			
09/20	14.0						EE				7.00	78	19.62		42			
09/20	15.0						EE				3.04	31	14.85		44			
09/20	16.0						EE				2.23	22	12.66		45			
09/20	17.0						EE				1.36	13	11.36		45			
09/20	18.0	19.0	1.2	13	6.0	8.2	EE	6.09	4.9	3.3	1.51	14	10.89	0.30	45			
10/24	0.0															0	0	525.89
10/24	1.0		0.5	8	6.0	7.8	EE	6.60	4.6	2.9	8.55	83	13.64	0.13	41			
10/24	2.0						EE				8.57	83	13.58		41			
10/24	3.0						EE				8.50	82	13.56		41			
10/24	4.0						EE				8.47	82	13.52		41			
10/24	5.0						EE				8.36	81	13.51		41			
10/24	6.0						EE				8.54	82	13.50		41			
10/24	7.0						EE				8.35	80	13.50		41			
10/24	8.0						EE				8.41	81	13.49		41			
10/24	9.0						EE				8.31	80	13.48		41			
10/24	10.0						EE				8.36	81	13.47		41			
10/24	11.0						EE				8.40	81	13.47		41			
10/24	12.0						EE				8.22	79	13.46		41			
10/24	13.0						EE				8.29	80	13.46		41			
10/24	14.0						EE				8.28	80	13.46		41			
10/24	15.0						EE				8.32	80	13.45		41			
10/24	16.0						EE				8.32	80	13.46		41			
10/24	17.1		0.6	8	6.2	8.1	EE	6.54	4.7	3.0	8.35	80	13.45	0.15	41			
10/24	18.0	18.6					EE				8.24	80	13.43		41			
11/16	0.0															7	0	525.37
11/16	1.0		0.5	8	5.8	7.5	EE	6.68	4.5	2.9	9.90	90	9.67	0.10	41			
11/16	3.0						EE				9.88	90	9.66		41			
11/16	6.0						EE				9.96	90	9.59		41			
11/16	9.0						EE				9.91	90	9.43		41			
11/16	12.0						EE				9.96	90	9.31		41			
11/16	15.0						EE				9.80	88	9.29		41			
11/16	18.2	18.9	0.4	8	6.2	7.7	EE	6.69	4.5	2.9	9.90	89	9.26	0.12	41			
	AVG.		0.5	10	7.0	8.8		6.51	4.3	2.7	8.44	82	13.73	0.09	42.3	1064	0	526.42
	MAX.		1.2	13	8.4	12.2		6.85	4.9	3.3	12.12	102	23.79	0.30	45.5	9500	0	528.46
	MIN.		0.3	8	5.5	7.3		6.09	3.9	2.4	1.36	13	4.85	0.04	39.8	0	0	524.65
	MEDIAN		0.4	9	7.1	8.2		6.55	4.2	2.6	8.32	88	13.46	0.08	41.3	2	0	526.15

EE= EQUIPMENT ERROR
LISTED pH DATA TAKEN BY FIELD INSTRUMENT IS CONSISTENTLY LOWER THAN IN-LAB pH ANALYSIS.

Quabbin Reservoir Special Samples

QUABBIN LABORATORY RECORDS 2000
(A2) RESERVOIR -- EAST ARM, ABOVE LEVEAU ISLAND

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
03/29	3.0						6.70			12.15	101	5.19		39			524.65
03/29	6.3						6.69			12.18	101	5.16		39			
03/29	9.5						6.67			12.13	101	5.15		39			
03/29	11.9						6.64			12.17	101	5.12		39			
03/29	14.9						6.62			12.15	101	4.98		39			
03/29	17.8						6.60			12.13	100	4.81		39			
03/29	19.3	19.4					6.58			12.15	100	4.80		39			
04/06	2.0						6.29			12.23	103	6.36		39			524.94
04/06	3.9						6.36			12.15	102	6.36		39			
04/06	6.0						6.42			12.13	102	6.33		39			
04/06	8.0						6.44			12.07	102	6.35		39			
04/06	9.9						6.45			12.05	101	6.34		39			
04/06	12.0						6.47			12.07	102	6.32		39			
04/06	14.0						6.48			12.00	101	6.31		39			
04/06	16.0						6.48			12.02	101	6.22		39			
04/06	18.3						6.49			11.98	100	6.16		39			
04/27	3.0						6.40			11.55	99	7.46		38			526.15
04/27	6.0						6.44			11.62	99	7.44		38			
04/27	9.0						6.45			11.61	99	7.44		38			
04/27	11.9						6.46			11.61	99	7.43		38			
04/27	15.0						6.47			11.63	99	7.35		38			
04/27	18.0						6.47			11.74	99	7.20		37			
04/27	18.9						6.46			11.85	100	7.21		37			
05/17	0.5						6.43			9.71	98	14.95		40			526.81
05/17	3.0						6.36			9.99	98	13.54		40			
05/17	6.0						6.40			10.43	99	11.88		39			
05/17	9.0						6.30			10.82	97	9.46		38			
05/17	12.0						6.29			10.86	96	8.85		38			
05/17	15.0						6.23			10.82	95	8.70		38			
05/17	18.0						6.20			10.77	94	8.63		38			
06/20	1.0						6.37			8.78	97	19.06		40			528.46
06/20	2.1						6.46			8.76	96	19.01		40			
06/20	3.0						6.54			8.64	95	18.85		40			
06/20	4.0						6.58			8.67	95	18.70		40			
06/20	5.0						6.67			9.10	97	17.71		39			
06/20	6.0						6.67			9.58	100	16.20		39			
06/20	7.0						6.64			9.51	98	15.68		39			
06/20	7.9						6.50			9.65	98	15.06		39			
06/20	9.1						6.40			9.45	94	14.25		39			
06/20	10.0						6.24			9.23	91	13.95		40			
06/20	11.0						6.02			8.76	85	12.86		40			
06/20	11.0						6.02			8.77	85	12.88		40			
06/20	12.0						5.98			8.74	84	12.39		40			
06/20	13.0						5.97			8.87	84	12.21		40			
06/20	14.1						5.93			9.05	86	11.96		39			
06/20	15.0						5.93			8.93	84	11.89		39			
06/20	16.0						5.92			9.01	85	11.66		39			
06/20	17.0						5.92			8.96	84	11.60		40			
06/20	18.0						5.91			9.01	84	11.45		39			
06/20	19.0						5.90			8.99	84	11.30		39			
06/20	20.1						5.86			8.94	83	11.20		39			
06/20	20.1						5.83			8.81	82	11.19		40			

QUABBIN LABORATORY RECORDS 2000
(A2) RESERVOIR -- EAST ARM, ABOVE LEVEAU ISLAND

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
06/20	21.0	21.5					5.81			8.48	79	11.14		40			
07/12	1.0						6.42			7.94	94	21.99		40			528.17
07/12	2.0						6.32			7.94	94	21.99		40			
07/12	3.0						6.35			7.84	92	21.84		40			
07/12	4.1						6.38			7.82	92	21.77		40			
07/12	5.0						6.40			7.76	91	21.72		40			
07/12	6.0						6.41			7.80	91	21.65		40			
07/12	7.0						6.40			7.91	91	20.98		40			
07/12	8.0						6.35			8.22	93	19.90		39			
07/12	9.0						6.27			8.41	93	18.63		39			
07/12	10.0						6.15			8.46	90	17.13		39			
07/12	11.0						6.03			8.40	87	15.62		40			
07/12	11.2						5.97			8.26	85	15.55		40			
07/12	12.1						5.86			8.19	83	14.77		39			
07/12	13.0						5.80			8.19	83	14.77		40			
07/12	14.0						5.71			7.84	78	13.86		40			
07/12	15.0						5.68			7.79	77	13.65		40			
07/12	16.0						5.67			7.84	77	13.42		40			
07/12	17.1						5.64			7.74	76	13.01		39			
07/12	18.0						5.60			7.64	74	12.67		40			
07/12	19.0						5.59			7.69	74	12.43		39			
07/12	20.1						5.58			7.79	75	12.22		39			
07/12	21.0	21.5					5.50			7.02	67	12.00		40			
08/09	1.0						6.35			7.71	93	23.42		40			527.82
08/09	2.0						6.40			7.70	93	23.38		40			
08/09	3.0						6.43			7.67	93	23.38		40			
08/09	4.0						6.44			7.81	94	23.32		40			
08/09	5.0						6.46			7.65	92	23.29		40			
08/09	6.0						6.47			7.65	92	23.23		40			
08/09	7.0						6.46			7.62	92	23.17		40			
08/09	8.0						6.41			7.55	90	22.71		40			
08/09	9.0						6.33			7.57	90	22.34		40			
08/09	10.0						6.15			7.14	84	22.01		41			
08/09	10.9						6.00			7.57	85	19.84		41			
08/09	12.0						5.82			7.58	82	17.48		41			
08/09	13.0						5.65			7.00	73	15.79		41			
08/09	14.0						5.54			6.55	66	14.55		41			
08/09	15.0						5.51			6.35	64	14.22		41			
08/09	16.0						5.47			6.12	61	13.71		41			
08/09	17.0						5.47			6.31	62	13.34		41			
08/09	18.0						5.46			6.29	62	13.16		41			
08/09	19.0						5.45			6.23	61	12.86		41			
08/09	20.0	20.1					5.41			5.85	57	12.56		41			
	AVG.						6.18			9.18	89	13.59		39			526.71
	MAX.						6.70			12.23	103	23.42		41			528.46
	MIN.						5.41			5.85	57	4.80		37			524.65
	MEDIAN						6.35			8.76	92	13.01		40			526.81

QUABBIN LABORATORY RECORDS 2000
(A) RESERVOIR -- EAST SOUTHEAST OF DEN HILL

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
03/29	1.2						6.19			11.84	99	5.55		45			524.65
03/29	2.0						6.20			11.68	98	5.53		45			
03/29	3.1						6.21			11.71	98	5.52		45			
03/29	4.0						6.23			11.60	97	5.52		45			
03/29	5.0						6.24			11.63	98	5.52		45			
03/29	5.9						6.24			11.76	99	5.52		45			
03/29	7.3						6.25			11.78	99	5.52		45			
03/29	8.9						6.26			11.68	98	5.52		45			
03/29	9.1	9.3					6.25			11.61	98	5.53		45			
04/06	0.9						6.14			11.85	100	6.40		45			524.94
04/06	2.0						6.24			11.81	99	6.23		45			
04/06	4.0						6.26			11.65	98	6.22		45			
04/06	6.0						6.28			11.59	97	6.20		45			
04/06	7.0						6.28			11.68	98	6.20		45			
04/13	1.4						6.36			11.11	94	7.18		45			526.15
04/13	3.4						6.32			11.06	93	7.14		45			
04/13	4.5						6.34			10.97	92	7.08		45			
	AVG.						6.25			11.59	97	6.02		45			525.25
	MAX.						6.36			11.85	100	7.18		45			526.15
	MIN.						6.14			10.97	92	5.52		45			524.65
	MEDIAN						6.25			11.68	98	5.55		45			524.94

(W1) RESERVOIR -- SOUTH END OF SOUTHWORTH ISLAND

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
03/29	2.0						6.26			11.80	99	5.47		45			524.65
03/29	4.0						6.26			11.86	99	5.46		45			
03/29	6.0						6.28			11.77	99	5.47		45			
03/29	9.8						6.29			11.84	99	5.47		45			
03/29	12.1						6.29			11.75	98	5.43		44			
03/29	14.1						6.29			11.74	98	5.44		45			
03/29	15.9						6.29			11.72	98	5.43		44			
03/29	18.0	19.5					6.30			11.66	98	5.43		45			
04/06	2.0						6.26			11.84	100	6.58		44			524.94
04/06	4.0						6.28			11.82	100	6.55		44			
04/06	6.0						6.29			11.69	99	6.55		44			
04/06	8.0						6.30			11.74	99	6.54		45			
04/06	10.0						6.30			11.66	99	6.50		44			
04/06	11.9						6.29			11.67	98	6.38		45			
04/06	14.0						6.28			11.67	98	6.35		44			
04/06	15.9						6.25			11.67	98	6.18		44			
04/06	18.0						6.22			11.69	98	6.02		45			
04/13	1.0						6.21			10.98	93	7.39		44			526.15
	AVG.						6.27			11.70	98	6.04		44			525.25
	MAX.						6.30			11.86	100	7.39		45			526.15
	MIN.						6.21			10.98	93	5.43		44			524.65
	MEDIAN						6.29			11.73	98	6.10		44			524.94

W2 -- RESERVOIR

DATE	DEPTH-M	BOTTOM	TURB	COLOR	CHLO	HARD	pH	STDALK	EPAALK	DOPPM	DOSAT	TEMPC	Fe	SPCOND	TOTCOLI	FECCOLI	ELEV
04/06	2.0						6.31			11.86	101	6.66		42			524.94
04/06	3.9						6.34			11.88	101	6.67		42			
04/06	6.0						6.36			11.75	100	6.67		42			
04/06	7.9						6.37			11.81	100	6.67		42			
04/06	10.0						6.38			11.82	100	6.67		42			
04/06	12.0						6.38			11.72	100	6.67		42			
04/06	14.0						6.38			11.63	99	6.67		42			
04/06	16.0						6.39			11.78	100	6.66		42			
04/06	18.0						6.38			11.67	99	6.64		42			
04/06	19.8						6.38			11.69	99	6.60		42			
	AVG.						6.37			11.76	100	6.66		42			
	MAX.						6.39			11.88	101	6.67		42			
	MIN.						6.31			11.63	99	6.60		42			
	MEDIAN						6.38			11.77	100	6.67		42			

QUABBIN LABORATORY RECORDS 2,000
SPECIAL RESERVOIR SAMPLES

SORT	CODE	SITE	DATE	DEPTH-M	TOTCOLI	FECCOLI
1	50	202	07/10/00	0	100	0
2	50	202	07/10/00	5	250	0
3	50	202	07/10/00	28	22	0
4	110	206	07/10/00	0	2	0
5	110	206	07/10/00	5	2	0
6	110	206	07/10/00	28	1	0
7	112	206(NORTH)	07/10/00	0	1	0
8	112	206(NORTH)	07/10/00	5	3	0
9	112	206(NORTH)	07/10/00	10	1	0
10	114	206(MID)	07/10/00	0	7	0
11	114	206(MID	07/10/00	5	2	0
12	114	206(MID)	07/10/00	18	1	0
13	118	206(SOUTH)	07/10/00	0	1	0
14	118	206(SOUTH)	07/10/00	5	3	0
15	118	206(SOUTH)	07/10/00	28	2	0
16	50	202	07/13/00	0	18	0
17	50	202	07/13/00	5	47	0
18	50	202	07/13/00	10	76	0
19	50	202	07/13/00	28	55	0
20	50	202	07/19/00	0	900	0
21	50	202	07/19/00	5	1100	0
22	50	202	07/19/00	18	2800	0
23	50	202	07/19/00	28	1100	0
24	50	202	07/20/00	0	800	0
25	50	202	07/20/00	5	900	1
26	50	202	07/20/00	18	1700	0
27	50	202	07/20/00	28	TNTC	0
28	50	202	07/20/00	34	60	0
29	55	3A(EAST)	07/20/00	0	760	0
30	55	3A(EAST)	07/20/00	5	2400	0
31	55	3A(EAST)	07/20/00	18	7300	0
32	55	3A(EAST)	07/20/00	28	1400	0
33	55	3A(EAST)	07/20/00	40	1500	0
34	56	3A(CENTER)	07/20/00	0	1900	LA
35	56	3A(CENTER)	07/20/00	5	1700	0

QUABBIN LABORATORY RECORDS 2,000
SPECIAL RESERVOIR SAMPLES

SORT	CODE	SITE	DATE	DEPTH-M	TOTCOLI	FECCOLI
36	56	3A(CENTER)	07/20/00	18	5000	LA
37	56	3A(CENTER)	07/20/00	28	2500	0
38	56	3A(CENTER)	07/20/00	35	1700	LA
39	57	3A(WEST)	07/20/00	0	3100	
40	57	3A(WEST)	07/20/00	5	TNTC	0
41	57	3A(WEST)	07/20/00	18	TNTC	0
42	57	3A(WEST)	07/20/00	25	1700	0
43	60	203	07/20/00	18	7500	0
44	60	203	07/20/00	28	2100	0
45	60	203	07/20/00	34	1600	0
46	70	203A	07/20/00	0	400	0
47	70	203A	07/20/00	5	2000	0
48	70	203A	07/20/00	24	700	0
49	110	206	07/20/00	0	100	0
50	110	206	07/20/00	5	540	1
51	110	206	07/20/00	24.2	400	0
52	110	206	07/20/00	35	120	0
53	112	206(NORTH)	07/20/00	0	20	0
54	112	206(NORTH)	07/20/00	5	100	0
55	112	206(NORTH)	07/20/00	7	100	0
56	112	206(NORTH)	07/20/00	10	600	0
57	116	206(EAST)	07/20/00	0	100	0
58	116	206(EAST)	07/20/00	5	260	0
59	116	206(EAST)	07/20/00	12	180	0
60	116	206(EAST)	07/20/00	16	120	0
61	118	206(SOUTH)	07/20/00	0	100	0
62	118	206(SOUTH)	07/20/00	5	540	0
63	118	206(SOUTH)	07/20/00	9	500	0
64	118	206(SOUTH)	07/20/00	13	1400	0
65	140	DEN HILL	07/20/00	0	TNTC	0
66	140	DEN HILL	07/20/00	5	TNTC	0
67	140	DEN HILL	07/20/00	17	400	0